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Future Meetings of the American Institute of Electrical Engineers

Place	Date	Nature	Manuscript Closing Date
New York, N. Y.	Jan. 25-29, 1932	Winter Convention	(Closed)
Milwaukee, Wis.	March 14-16, 1932	District Meeting	(Closed)
Providence, R. I.	May 4-7, 1932	District Meeting	Feb. 4, 1932
Cleveland, Ohio	June 20-24, 1932	Summer Convention	March 20, 1932
Vancouver, B. C.	Aug. 29-Sept. 2, 1932	Pacific Coast Convention	May 29, 1932
Baltimore, Md.	October-1932	District Meeting	July-1932
Memphis, Tenn.	November-1932	District Meeting	August-1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
Am. Engg. Council	Washington, D. C.	Jan. 14-16	L. W. Wallace, Secy., 744 Jackson Pl. N. W., Washington, D. C.
A.I.M.E. annual meeting	New York, N. Y.	Feb. 15-18	A. B. Parsons, Secy., 29 W. 39th St., New York, N. Y.
Am. Physical Soc.	Cambridge, Mass.	Feb. 25-27	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
A.S.C.E. annual meeting	New York, N. Y.	Jan. 19-22	Geo. T. Seabury, Secy., 33 W. 39th St., New York, N. Y.
Am. Soc. Heat. & Vent. Engrs. winter convention	New York, N. Y.	Jan. 25-28	A. V. Hutchinson, Secy., 29 W. 39th St., New York, N. Y.
Am. Soc. Refrig. Engrs. annual meeting	Cleveland, O.	Jan. 26-30	Miss H. Peffer, 37 W. 39th St., New York, N. Y.
N.E.L.A. Engg. National Section group meeting	New York, N. Y.	Feb. 1-5	A. J. Marshall, 420 Lexington Ave., New Yoik, N. Y.
N.E.L.A. No. Cent. Div. Engg. Section	St. Paul, Minn.	Feb. 22-23	J. W. Lapham, 803 Plymouth Bldg., Minneapolis, Minn.
N.E.L.A. Southwestern Div.	Hot Springs, Ark.	April 25-28	A. J. Marshall, 420 Lexington Ave., New York, N. Y.
So. American Electrotechnical Congress	Buenos Aires, Argentina	July 4-11	R. F. Ascher, Secy., Paseo Colon 185, Buenos Aires, S. A.

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Front Cover

"Liberty in a new light." The new floodlighting installation for New York Harbor's famous Statue of Liberty provides an intensity of 30 footcandles for the statue itself and 15 footcandles for the base. This is accomplished by 96 1,000-watt projectors in the star-shaped parapet around the base and many smaller units at other parts of the statue; the torch is lighted by fourteen 1,000- and six 100-watt units.

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Table I—Radio Interference and Corona Formation Voltage Data for Pin Insulators

Insulator Number	Nominal Rating KV	Initial Radio Interference Data: Insulator Potential KV	Initial Radio Interference Data: Location on Insulator	Insulator Visible Corona Data: Head KV	Insulator Visible Corona Data: Pin KV	Shells* 1-2 KV	Shells* 2-3 KV	Shells* 3-4 KV	Remarks — MEAN ATMOSPHERIC CONDITION: BAROMETRIC PRESSURE 757.2 MM. OF HG. TEMPERATURE 21.3 DEGREES CENTIGRADE. WET BULB TEMPERATURE 55.3 DEGREES FAHRENHEIT. DRY BULB TEMPERATURE 70.4 DEGREES FAHRENHEIT. RELATIVE HUMIDITY 36 PER CENT
A-4	66	20.4	PIN	20.4	18.4	30.5	25.7	-	Solder coating in conductor and tie wire grooves.
B-5	66	23.0	HEAD	23.0	32.7	62.2	86.6	-	Silver and Bismuth coating on head. Zinc thimble in pin hole.
B-6	66	23.5	HEAD & PIN	23.5	23.5	67.6	75.0	-	Silver and Bismuth coating on head and in pin hole.
D-4	66	8.1	HEAD	8.5	52.0	53.6	42.9	-	Standard porcelain insulator with ¾ in. malleable thimble.
D-5	66	29.3	CAP TO PORC.	30.2	37.1	50.3	NOT TAKEN	-	Malleable cap on head ¾ in. malleable thimble, discharge cap to porcelain.
D-6	66	32.1	CAP TO PORC.	32.1	40.4	54.4	58.9	-	Malleable cap on head ¾ in. malleable thimble, discharge cap to porcelain.
D-6a	66	42.4	BETWEEN SHELLS 2&3	47.6	45.7	43.4	42.4	-	Crevices head and thimble filled with Portland Cement.
D-6b	66	17.9	HEAD	17.9	71.5	97.1+	70.7	-	Crevices head and thimble filled with Portland Cement, between shells with Pothead Compound.
D-7	66	25.2	PIN	27.0	25.2	46.5	51.9	-	Malleable cap on head ¾ in. malleable thimble, discharge cap to porcelain.
D-7a	66	60.7	HEAD	60.7	86.7	53.8	56.8	-	Crevices head and thimble filled with Pothead Comp'd. Discharge at head.
D-7b	66	38.7	HEAD	38.7	64.1	91.6+	91.6+	-	Crevices at head, shells, and thimble filled with Pothead Compound. Discharge over compound at head 45.3 KV.
F-4	70	25.2	HEAD	25.5	38.3	44.7	41.1	37.4	Sanded head coated with electrolytic copper ¾ in. malleable thimble.
F-5	70	9.5	HEAD	9.5	← NOT TAKEN →				Same as F-4. Discharge in fault in metal coating.
G-1	70	12.3	HEAD	12.3	38.5	81.1+	81.1+	-	Standard Insulator. Corona on head at tie and in pin hole around metal.
G-2	70	50.3	HEAD	50.3	81.1+	81.1+	81.1+	-	"Nostatic" coating on head and in pin hole.
G-2a	70	40.3	HEAD	40.3	← NOT TAKEN →			-	After 10 A.I.E.E. Std thermal test cycles, 35 impulse flashovers at 450 Kv. maximum, and five hours heavy conductor and tie wire vibration, corona first formed where impulse arcs destroyed the conducting coating on the head.
G-3	70	59	HEAD	59.0	80.0+	80.0+	80.0+	-	"Nostatic" coating on head and in pin hole.

*Shells numbered from head to pin

corona formation and radio interference are coincident was determined by a great many tests using insulators so designed and treated that the first corona occurs in locations easily observed in a darkened room. Some of these test data are shown in Table I.

Radio Interference and Visual Corona Formation Voltages

At the time the investigation of radio interference was started, it was known that in general the interference from pin type insulators is more pronounced than that from the suspension type; also, that more interference was radiated from high voltage than from low voltage pin type insulators. For these reasons, practically all tests have been confined to pin and pedestal insulators rated at from 66 to 73 kv. The radio interference and visual corona formation voltage tests were made with apparatus connected as shown in Fig. 1. Great care was exercised to avoid extraneous interference from the testing equipment. To prevent interference from minute discharges between metallic parts in close proximity to each other, all pieces of hardware associated with the experimental apparatus were bonded carefully either to the high voltage conductor or to the ground. A polished ½-in. galvanized iron pipe (0.83 in. outside diameter) shielded at each end, was used as the conductor; this pipe was free from corona for all voltages up to 100 kv.

Tests on Pin Insulators

A few representative determinations of the radio interference and corona formation voltages for pin insulators are given in Table I. The tabulated values show that radio interference and visible corona occur at the same value of insulator voltage except when the corona starts in locations not in view.

The unshielded insulators started radiating interference and showed visible corona at the surprisingly low voltages of from 8.0 to 12.2 kv. to neutral or approximately 25 per cent of the normal operating voltage. However, all of the shielded insulators except F-5 showed a marked improvement in the radio interference formation point, and only one insulator G-2 was free from radio interference at normal operating voltage. The lower case subscript letters (Table I) indicate insulators treated or modified as shown under the remarks in the table.

It may be observed that improvements were effected by sealing all crevices with cement or compound; the radio interference voltage was increased thereby from 32 to 123 per cent.

Fundamentals of Preventing Insulator Radio Interference

Because of the nature of the disturbing electrical discharges on insulators there are at least three methods of attack to eliminate them. These are to:

1. Design the insulator in such a manner that no regions of overstressed air exist under normal operating conditions.

2. Provide conducting coatings to act as dielectric flux distributors at the head, in the pin-hole, and on other necessary parts.

3. Displace the overstressed air with an insulating compound dielectrically strong enough to withstand the potential.

From at least one standpoint, method 1 is the most desirable of the three because it employs no auxiliary material which may be subject to deterioration in service. This method, however, is the most radical departure from present practise and therefore probably will require a longer development period if found practicable at all. If method 2 employing a dielectric flux distributor is used, the conducting material must be in such intimate contact with the solid dielectric that all air between the conducting coating and the porcelain

or glass is excluded. The use of method 3 requires that all air in regions subject to being overstressed to the ionizing point be displaced by an insulating compound.

Some difficulties are encountered in employing any of these three methods. Conducting coatings must remain at all times in intimate contact with the insulator material, and must withstand weathering, electrolysis due to leakage currents, temperature changes, and abrasion due to conductor and tie wire motion. Further such coatings must not terminate in positions that will overstress the air in other parts of the dielectric circuit, and the flashover value of the insulator must not be reduced below the required factor of safety. If insulating compound is used, it must withstand weathering, stay in place through the extremes of temperature to which it may be subjected, and not be displaced by the motion of the conductor and tie wire to the extent of impairing its effectiveness.

Although the design of a satisfactory insulator of practical proportions and which will be suitable for mass production apparently is not a simple problem, it is believed to be entirely possible to meet the requirements outlined and build an insulator entirely free from radio interference at a safe margin above its normal operating voltage.

Insulator Corona Current Investigation

The magnitude and character of the corona current of high voltage insulators is of great interest and importance because these characteristics are direct indications of the radio interference radiation produced. Corona current is not easily studied because (1) it is quite small, attaining maximum values of approximately 40 microamperes for normal voltage on a standard 66-kv. insulator; (2) it is obscured by the insulator charging current which is approximately 0.4 milliampere maximum or 10 times the corona current for an insulator of this size; and (3) it has superimposed oscillations of very high frequency.

An instrument suitable for the investigation of currents of these magnitudes and characteristics must have a high sensitivity and be capable of responding faithfully to high frequencies. The device that meets these requirements most satisfactorily is the low voltage cathode ray oscillograph. Because of the low anode-cathode voltage and resulting low velocity of the electron stream, this instrument has the highest sensitivity of all of the cathode ray oscillographs; and the cathode beam diffusion due to the relative immobility of the positive focusing ions is not excessive for beam speeds of 3×10^6 cm. per sec. on the fluorescent screen.

Although the cathode ray oscillograph is well suited to the study of high frequency discharges, it will not of itself separate the corona current from the charging current. To overcome this difficulty the circuit shown in Fig. 2 was devised to balance out the charging current leaving only the corona current to produce deflection. With this circuit arrangement, it is possible by adjusting R_1 and C_3 to make the vertical deflecting potential on the oscillograph zero for all insulator voltages up to the critical corona formation voltage. At this critical voltage and for higher voltages, the oscillograph vertical deflecting voltage is proportional to the instantaneous value of the insulator corona current in R_2. This condition obtains because C_1 is free from corona. A glass insulator with dielectric flux distributing coatings on the head and in the pin-hole, and found by test to be free from corona up to 50 kv., was used for C_1 when the accompanying cathode ray oscillograms were taken.

The horizontal deflecting or sweeping voltage for the oscillograph was obtained from a neon oscillator connected as shown in Fig. 2. This type of oscillator produces practically a straight line time axis that can be operated over a wide range of sweeping frequencies by the adjustment of R_3 and C_4. This sweeping oscillator can be synchronized readily with the frequency producing the phenomena under observation so that a stationary image either for observation or recording photographically is obtained. To eliminate stray dielectric fields a grounded wire cage 5x5x6 ft. high was used to shield all apparatus associated with the oscillograph and neon oscillator.

Voltage was applied to the laboratory line and increased to a value just below the critical corona voltage for the insulator under test. At this voltage,

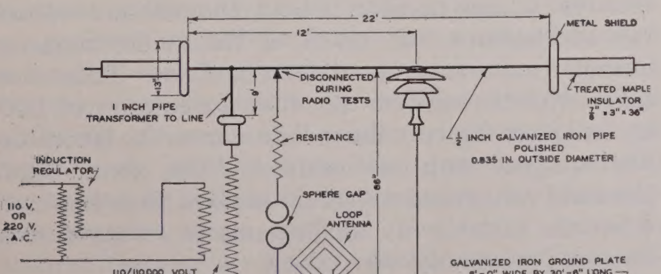

Fig. 1. Schematic diagram of apparatus for laboratory investigation of radio interference and corona formation voltages on pin insulators

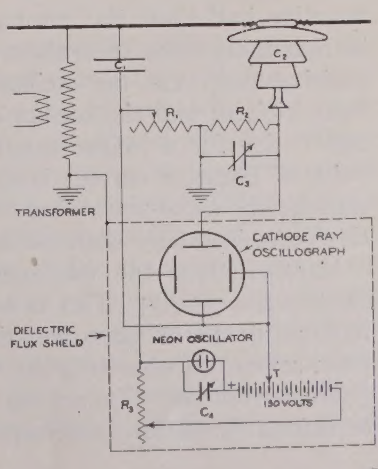

Fig. 2. Circuit for obtaining cathode ray oscillograms of insulator corona current. Note that the insulator charging current is balanced out

resistance R_1 and capacitance C_3 were adjusted to make the vertical deflecting voltage zero. These adjustments were made while the neon oscillator was sweeping the cathode beam over the time axis, conditions under which any slight inaccuracies in balance were detected readily by the deviation of the beam from a straight line. When this balance was established accurately, a series of corona current oscillograms was taken for the insulator at various conductor to pin voltages from 10 to 40 kv., r.m.s., in increments of 5 kv.

In Fig. 4 is shown a series of corona current oscillograms taken on a standard three-shell 66-kv. porcelain insulator with a $^3/_4$-in. malleable thimble cemented in the pin-hole. Oscillogram G (40 kv.) shows the normal corona current for this insulator operating on a three-phase transmission line at a line potential of 69.3 kv. Atmospheric conditions were representative and normal, air density being 1.006 and the absolute humidity 9.4 g. per cubic meter.

Oscillograms reproduced in Fig. 5 show that when the ionization gradient is reached, the current rises to a maximum value quite abruptly during the positive half

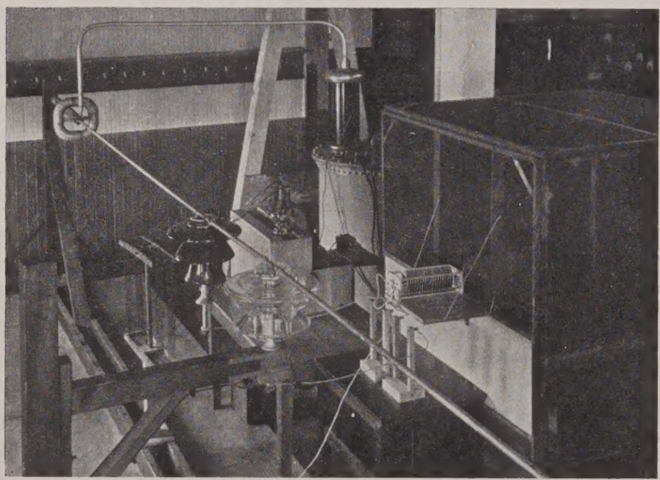

Fig. 3. Apparatus for obtaining cathode ray oscillograms of insulator corona current

cycle and decays rapidly with considerable oscillation, reaching zero practically coincident with the occurrence of maximum voltage on the insulator. During the negative half cycle the corona current does not reach its maximum value in so short a time interval as in the positive half cycle, the oscillations appear to be much more violent, and the corona current is sustained at a high value for a longer time. The higher sustained value of negative current is shown clearly by the fact that for the same line voltage the area under the negative wave is greater than under the positive wave.

Unfortunately the oscillograms do not show the oscillations clearly. This is because that in order to form an image on photographic film it is necessary to trace several successive cycles of corona current on the fluorescent screen. On account of the chance character of corona formation, successive cycles of corona current are not alike, and where the oscillations are the greatest, the variation in successive figures is largest. This variation in the registration of successive cycles is shown on the oscillogram by variations in intensity of exposure and sharpness of the image.

Corona current oscillograms were taken also on a special three-shell 66-kv. porcelain insulator with a silver and bismuth coating on the head and in the pin-hole. This insulator (No. B-6 of Table I) was practically identical with the previous one except for the addition of the metallic coatings. In this case no corona current was observed below 30 kv. The difference in the character of positive and negative corona currents on this insulator was greater than for the standard insulators. The positive current shows much less oscillation than the negative, and the duration of the positive current was observed to be much shorter than that of the negative.

Metallic dielectric flux distributors on this special insulator greatly improved the characteristics from the standpoint of radio interference. The interference starting voltage was increased from slightly above 10 kv. to 23.5 kv., and the maximum corona current at 40 kv. was reduced from 40 to 11 microamperes. However, the voltage gradient was noted to be excessive at the edges of the metallic coatings on the head and in the pin-hole at 23.5 kv., which is only 61.6 per cent of normal operating voltage.

Similar oscillograms were taken for a standard 70-kv. one-piece glass insulator without any treatment to prevent corona formation. These oscillograms show the same general corona current characteristics obtained with the standard porcelain insulator. Cathode ray oscillograms for a similar glass insulator with high resistance iridescent dielectric flux distributors on the head and in the pin-hole revealed no corona current for voltages up to 40 kv. when these coatings were in good condition.

Oscillographic Study of Radio Receiver Output

In order to determine the value of the cathode ray oscillograms of insulator corona currents for indicating the interfering noise that will be produced in a radio receiver, a large number of both Duddell and cathode ray oscillograms was taken of the audio frequency output from a superheterodyne receiver. These were taken with the receiver tuned for a frequency of 1,000 kc. and receiving only the radiation from the laboratory line equipped with one insulator. The circuit conditions and voltages used were the same as those employed when the cathode ray oscillograms of corona current discussed previously were taken.

A typical set of oscillograms for this portion of the investigation may be seen in Fig. 5. In these the polarity and magnitude of the insulator voltage as well as the audio frequency current output of the radio receiver are shown for the standard, three-shell, 66-kv. porcelain insulator for which corona current oscillo-

grams were shown in Fig. 4. It should be observed that the oscillations in the audio output have frequencies reaching values of 5,000 cycles per sec., which is the natural period of oscillation for the oscillograph vibrator element. Therefore the amplitude indications are not very reliable. Notwithstanding this fact, the oscillograms show accurately the beginning of the corona discharge and quite accurately the end of the corona discharge with reference to each half cycle of the insulator voltage. At 14.1 kv. maximum, there is just the slightest trace of interference, occurring at practically the crests of the voltage waves. At 21.2 kv. maximum, the corona starts at a very small electrical angle and at 28.3 kv. maximum, it appears at the zero point of the voltage wave. For higher voltages the corona starts before the voltage wave reverses polarity. For all values of voltage the corona discharge stops at the crest of the voltage wave. This is shown by the fact that at that point the oscillations stop. At the higher voltages the smooth decay of current following the oscillations is due to the recovery of the receiving set from overloading.

The phenomenon of obtaining critical ionizing voltage gradients on the insulator at zero, and even with opposing conductor potentials, is due to the large space charge established in the space and on the insulator surface surrounding the conducting materials where ionization has taken place during the previous half cycle. This is brought out in greater detail in the following discussion.

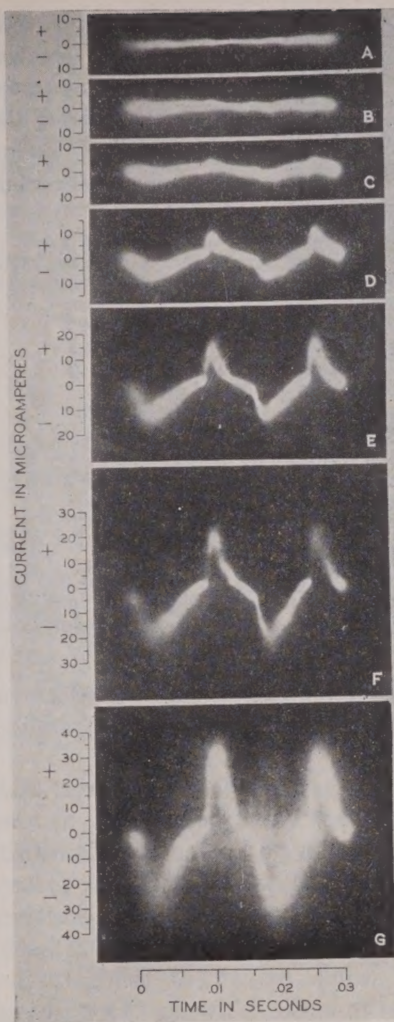

Fig. 4. Cathode ray oscillograms of corona current for a standard 66-kv. porcelain pin type insulator

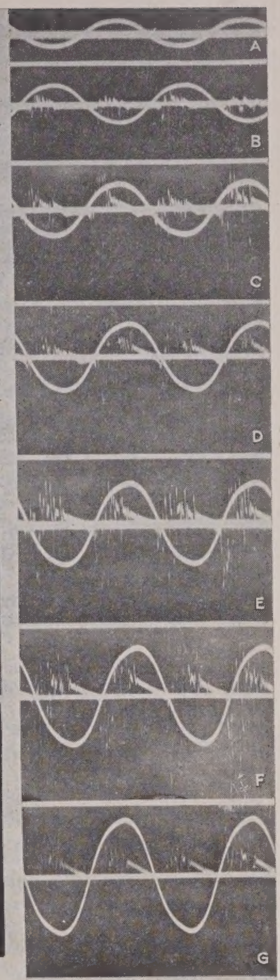

Fig. 5. Insulator voltage (60 cycle) and output of radio receiver showing noise from corona on insulator of Fig. 4

	Insulator kv. conductor to pin r.m.s.	maximum
A—	10	14.1
B—	15	21.5
C—	20	28.3
D—	25	35.4
E—	30	42.5
F—	35	49.5
G—	40	56.6

Test conditions (Figs. 4 and 5)	
Barometric pressure	756.0 mm.
Temperature, dry bulb	21.6 deg. cent.
wet bulb	15.3 deg. cent.
Relative humidity	50.0 per cent
Absolute humidity	94.0 g. per cu.m.

A Theory of the Formation of Insulator Corona

A theory of the phenomena associated with corona formation on an insulator can be developed by assuming the initial half cycle of conductor voltage to be either positive or negative. For the following discussion the initial polarity is assumed to be negative and the ionization of the air surrounding the conducting parts and in zones of high voltage stress is assumed to be only the normal atmospheric value at the instant the voltage first is applied.

During the initial negative half cycle, the dielectric field of the negatively charged conductor repels the free electrons and negative ions in the regions of high voltage gradient; when the critical ionizing voltage gradient is reached, they bombard the air molecules with such violence that ionization by collision results. The additional electrons and negative ions produced by collision are repelled from the conducting material by the electric field, and form the major part of an outside negative space charge. The heavy immobile positive ions move relatively slowly toward the conductor in the regions of ionization. In this manner corona increases and the positive ion space charge that accumulates due to the relative immobility of the positive ions subtracts from the negative field of the conductor until the crest of the voltage wave is reached. At this point ionization stops because the space occupied by the corona is completely ionized; the voltage gradient at the outside boundary of the corona discharge is just equal to the critical value and must decrease below this value as the conductor voltage decreases. For the negative conductor condition under consideration the positive space charge limits the corona to a comparatively small discharge distance. Many of the free electrons are swept out of the ionization zone and the loss of positive ions by recombination adjacent to the conductor thereby is reduced to a relatively small number. Large numbers of positive ions always are present therefore adjacent to the conductor; this is such a favorable position that a comparatively small

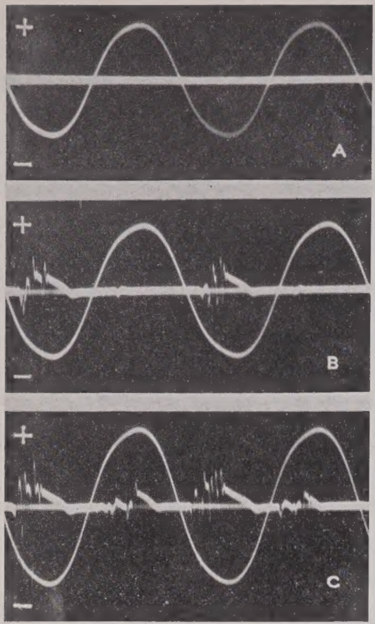

Fig. 6. Insulator voltage and radio receiver output showing more interference during the negative than during the positive half cycles.

	Insulator kv. conductor to pin r.m.s.	maximum
A—	30....	42.5
B—	35....	49.5
C—	40....	56.6

Barometric pressure 760.0 mm.
Temperature dry bulb 21.5 deg. cent. wet bulb 16.0 deg. cent.
Humidity relative 56.0 per cent absolute 10.6 g. per cu.m.

Porcelain insulator (66 Kv.) with silver and bismuth coating on head and in pin-hole

positive space charge will reduce greatly the field of a large negative conductor voltage at the outside boundary of the corona discharge.

After the negative voltage wave passes the crest and starts to decrease, the negative space charge at the outer boundary of the corona no longer is replenished by new ionization; hence it begins to diffuse and be lost by recombination. This action releases the positive space charge and allows it to move more rapidly back toward the conductor, which movement tends to increase the gradient in the space between the positive space charge and the conductor. Because of the decrease in conductor potential, ionizing voltage gradients prior to actual reversal of conductor potential are reached only when the space charge is very large. The latter phenomenon does occur, however, for all maximum applied voltages in excess of approximately twice the maximum visual critical corona voltage.

When the conductor voltage reverses and becomes positive after the described phenomena have taken place, the dielectric flux of the residual positive space charge adds to the field of the positive potential on the conductor. The addition of those fluxes causes the critical ionizing voltage gradient to occur at lower and lower values of instantaneous positive conductor voltages as the maximum conductor voltage is increased above the visual critical corona value. The resultant positive field accelerates the electrons in the surrounding space, and when high velocity collisions occur with molecules of air, ionization is produced. Large numbers of the electrons liberated are swept from the field and removed by the conductor, leaving more immobile positive ions to add to the positive space charge. This increase in space charge increases the dielectric flux density and extends the ionizing voltage gradient to a far greater distance from the conductor than would be possible with the conductor voltage acting alone. When the crest of the positive voltage wave is reached, the voltage gradient is at maximum and the corona discharge stops because the space occupied by the corona is completely ionized; the decrease in the conductor voltage makes ionization at a greater distance from the conductor impossible. As the conductor potential decreases it drops below space charge potential and a field is established between space charge and conductor. The field produces ionizing voltage gradients before the conductor voltage reverses, when the space charge potentials are very high. This phenomenon occurs for maximum applied voltages in excess of approximately twice the maximum visual critical corona voltage.

During the rise in voltage on the positive half cycle a much larger positive space charge is established than that produced during the same period of the negative half cycle. This is because when the conductor is positive, the positive space charge flux adds to the conductor field and extends the ionization gradient, when it is negative, the positive space charge flux subtracts from the negative conductor field at the outside corona boundary.

When the conductor voltage reverses and becomes negative following the establishment of a large positive space charge in the manner just described, a very high voltage gradient is produced between the negative conductor and the residual positive space charge because of the very short distance between them. When this voltage gradient reaches the critical ionizing value (which may occur before the voltage actually becomes negative) breakdown occurs in the form of minute arcs which neutralize the space charge. These corona arcs produce sudden changes in the electric circuit conditions, thereby causing high frequency oscillations of a violent character.

Radio Interference from Positive and Negative Corona

Near the critical corona formation voltage the electric circuit oscillations and the electromagnetic radiation resulting from them are inherently much worse for 60-cycle a-c. circuits when the conductor is negative than when it is positive. Theoretical considerations outlined in the preceding paragraphs indicate that this condition is to be expected and experimental investigations show a very decided polarity effect under certain conditions. For the special 66-kv. porcelain insulator with silver and bismuth coatings on the head and in the pin-hole, oscillograms taken show a very striking polarity effect in the interference radiation. (See Fig. 6.)

From the experimental investigations it appears that the marked difference in radio interference when the line is positive and when it is negative, respectively, can be observed only when the insulator has a definite critical corona formation voltage. When the voltage is increased far above this critical value, the polarity effect becomes less marked and at still higher voltages probably would disappear almost entirely. This phenomenon accounts for the fact that practically no

interference polarity effect was observable in the tests on standard insulators. (See Fig. 4.) On such insulators there is a heterogeneous group of visual critical voltage gradients that cause corona to form in small areas at various locations for every different value of insulator voltages from approximately 25 per cent normal operating voltage up to the flashover value. There the polarity effect is obscured because when sufficient voltage is applied to produce appreciable corona on the insulator, the regions that go into corona at low voltage are subjected to an excessive voltage gradient and therefore produce practically the same interference on both positive and negative half cycles.

Summary

The findings of this study may be summarized as follows:

1. Standard multi-shell pin type insulators of conventional design are susceptible to corona formation at three different points.

2. Radio interference and visible corona formation for clean insulators start at the same voltage.

3. Radio interference from insulator corona may be reduced by (a) designing the insulator so as to eliminate regions of overstressed air; (b) providing conducting coatings on different parts to act as dielectric flux distributors; and (c) displacing the overstressed air with an insulating compound.

4. Insulator corona current can be separated from the charging current and studied independently by means of the cathode ray oscillograph.

5. Duddell oscillograms of the line voltage, and the audio frequency output of a radio set receiving the radiation from an insulator or other source of corona, provide an excellent means for studying certain corona characteristics.

6. The radio interference radiation from an insulator having a definite critical corona voltage shows a decided polarity effect for all corona voltages up to approximately twice the critical disruptive value.

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Engineering Features of Three-Power Locomotives

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Locomotives for operation from either an external distribution system or an internal power source are especially well adapted to service over portions of road which for economic reasons cannot be completely electrified. Some of the more important engineering features of this type locomotive are outlined in this article.

THE THREE-POWER locomotive has taken its name from the fact that it may operate either from an external power source, which may be either a third-rail or overhead distribution system, or from two internal sources. The internal sources consist of a storage battery and a generator driven by an internal combustion engine. While the locomotive may be operated from the battery alone, operation on internal power usually is carried out with the generator running in parallel with the battery. The New York Central Railroad now has in service 36 locomotives of this type. These are used primarily in the elimination of steam service on the "West Side" tracks of New York City where the complete electrification with external power would be extremely impractical if not almost impossible. With the advent of electrified suburban passenger service from Hoboken, N. J., the Delaware, Lackawanna and Western Railroad also has put into service two three-power locomotives to aid in eliminating steam from its Bergen (N. J.) tunnels. These are used in a combination of transfer and switching service between that railroad's yards in Jersey City (adjacent to the Hoboken passenger terminal) and the Secaucus yards about 3.5 miles distant.

Perhaps the most outstanding feature of the three-power locomotive is its great flexibility. On both the New York Central and the Lackawanna systems the

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service demanded a self-propelled locomotive capable of handling the heaviest type of switching and short transfer work, as well as road freight and transfer service on external power.

Service on the New York Central consists of switching and transfer work in and between yards at three different points on its New York City tracks, with many sidings leading into warehouses and industrial buildings, as well as much trackage on city streets. On the Lackawanna system the transfer work consists of hauling heavy trains at relatively high speeds on external power between the two yards mentioned previously; the switching, which must be done entirely on internal power, consists of hauling these trains into the yards, and partially breaking them up, making up outgoing trains, and hauling them to the electrified tracks. To meet needs of this character the three-power locomotive was developed.

Although the operating voltages of the two railway systems mentioned are widely different (New York Central 600 volts d-c.; Lackawanna 3,000 volts d-c.) the general characteristics and scheme of operation of both locomotives are quite similar. (See Table I.) When using external power the unit performs exactly

Table I—Specification Data for N.Y. Central and Lackawanna Three-Power Locomotives

	N.Y.C.	D.L. & W.
Weight of locomotive in running order	257,000 lb.	248,000 lb.
Rated voltage on external power	600 (3rd rail)	3,000 (trolley)
Continuous hp. on external power	1,300	1,450
Hourly hp. on external power	1,665	1,600
Continuous tractive effort	24,600 lb	22,200 lb.
Hourly tractive effort	34,100 lb	25,200 lb.
Speed on external power at continuous tractive effort	19.8 mi. per hr.	24.5 mi. per hr.
Speed on external power at hourly tractive effort	18.3 mi. per hr.	23.8 mi. per hr.
Maximum tractive effort (25 per cent adhesion)	64,250 lb.	62,000 lb.
Traction motors		
Number	4	4
Type	Axle-hung	Axle-hung
Voltage	600	1,500/3,000
Gearing	72/17	72/17
Ventilation	Forced	Forced
Oil engine		
Type	Ingersoll-Rand solid injection	Ingersoll-Rand solid injection
Horsepower	300	300
Traction generator	200 kw	200 kw.
Battery		
Type	Exide Ironclad TL-27	Exide Ironclad MVA-21
Number of cells	240	360
Ampere-hour capacity at 6-hr. rate of discharge	650	340
Kw-hr. capacity at 6-hr. rate of discharge	301	242
Average voltage at 6-hr. rate of discharge	464	712
Connection of cells	Series	Series
Grounded at	Negative	Negative
Control		
Type	Electro-pneumatic, non-automatic	Electro-pneumatic, non-automatic
Motor combinations on external power	3	2
Motor combinations on internal power	3	3

as a straight electric locomotive although the engine-generator set may be run to charge the battery. On non-electrified tracks, power may be taken from the battery alone; however, if the engine is running, traction and auxiliary power are taken entirely from the engine-generator set up to its capacity, above which the battery automatically assumes the excess load. On light loads the engine-generator may run the locomotive and charge the battery at the same time.

General Requirements for Internal Power Plant

The average power required for switching service is small while the peak demands are relatively large. The theory upon which internal power operation of the three-power locomotive is based is that the battery will

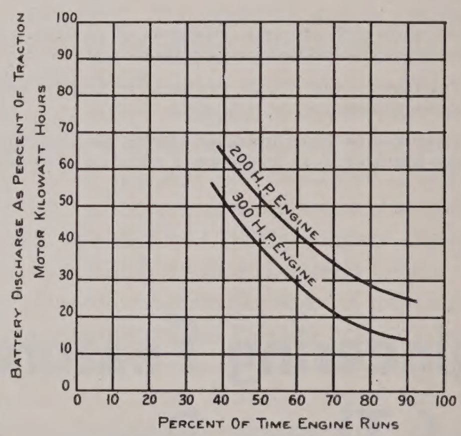

Fig. 1. Battery discharge in heavy switching service on internal power only, as a function of time that oil engine is running

provide the excess power required for the peak demands, thereby allowing the engine size to be cut to a minimum. Extensive tests to determine the actual extent of these power requirements in heavy switching service on internal power were run in 1928 on the first New York Central locomotive built. The average output for the maximum observed day for three-shift service was approximately 500 kw-hr. which gives an average load of 62.5 kw. per eight-hour shift. The average work for 65 shifts of three-shift service was 447 kw-hr. per shift. Frequently peak loads as high as 800 kw. were recorded, which is more than twelve times the maximum observed average load per eight-hour shift.

In later tests made on the Lackawanna locomotives, the ratio of the average power required in switching to that required in transfer work proved to be approximately 50 kw. to 450 kw. or 1 to 9. It is believed that this is the first case where actual data have been obtained which show the relative amount of work done on the main and yard tracks. Switching service in these tests called for frequent short periods of operation at

from 200 to 400 kw. with peaks of 800 kw., while transfer work had peaks as high as 3,000 kw.

For long battery life and reasonable maintenance, the battery discharge for each 24 hours the locomotive is operating in three-shift service should be limited to 125 per cent of the total capacity at the six-hour rate. To limit the battery discharge to this value successfully it is essential that the correct generator characteristic be used. This characteristic should be such as to insure the engine-generator unit carrying the entire load up to its capacity, but not to recharge the battery so rapidly that the engine must be shut down frequently to prevent overcharging. Without the engine the battery must of course supply the entire load, which results in the discharge over a 24-hr. period being considerably greater than with the engine running most of the time. Initial tests showed that the engine should be run at least 70 per cent of the time to meet these discharge limitations. However, a generator characteristic low enough to insure engine operation 70 per cent of the time is too low to give the battery an equalizing charge; therefore two generator characteristics are necessary; (1) a normal characteristic for regular operation, and (2) a higher or equalizing characteristic for use periodically to give the battery a gassing charge.

Minimum size of the battery is fixed by the traction motor characteristics and locomotive weight on one hand and speed requirements on the other. The former determine the maximum current which may be drawn from the battery as limited by adhesion, and the latter the number of cells. With traction motors in parallel the total current values for the New York Central locomotive at various adhesions range from approximately 2,500 to 3,700 amperes. A battery selected for this locomotive must be large enough to deliver these currents and to carry successfully at least 4,000 amperes for a period long enough to blow the 2,500-ampere battery fuses. Because of the decreased available capacity of the battery at high discharge rates, it is not practical to operate this type of locomotive on internal power at high adhesion and high speed for any great length of time. However, the extreme load conditions given above are possible for short periods and must be met successfully in practical operation.

In case of necessity it is possible to operate these locomotives at high adhesion over considerable distances by running at reduced speeds with the motors in series or series-parallel. In such cases the current to the motors is reduced to one-quarter or one-half of the value which would be required with the motors in parallel for the same total tractive effort. As the engine-generator set will continue to deliver its full power, all of this reduction in current is taken from the battery discharge rate, thus greatly increasing its available capacity. In addition to this, the increase in available kilowatt-hour capacity of the battery increases the duration of the movement and to this extent increases the kilowatt-hours delivered by the engine, thus further increasing available mileage. For fast and responsible operation of the locomotive it is advantageous to have the battery voltage near the rated voltage of the traction motors.

Internal Power Plant of the New York Central Locomotive

As a result of the initial tests and the weight and speed considerations just outlined, a design for the New York Central locomotive was adopted to meet the following specifications:

Battery short time current rating—2 min.—3,000 amperes
Engine hp.—300
Assumed time engine running—85 per cent
Maximum amount battery may be discharged in 24-hr. period (125 per cent of capacity at 6-hr. rate):
- 812 ampere-hr. in 24 hr.
- 271 ampere-hr. per 8-hr. shift
- 114 kw-hr. per 8-hr. shift (average discharge volts 420)

See Table I also

Effect upon the battery discharge of the percentage of time the engine operates is shown in Fig. 1. These

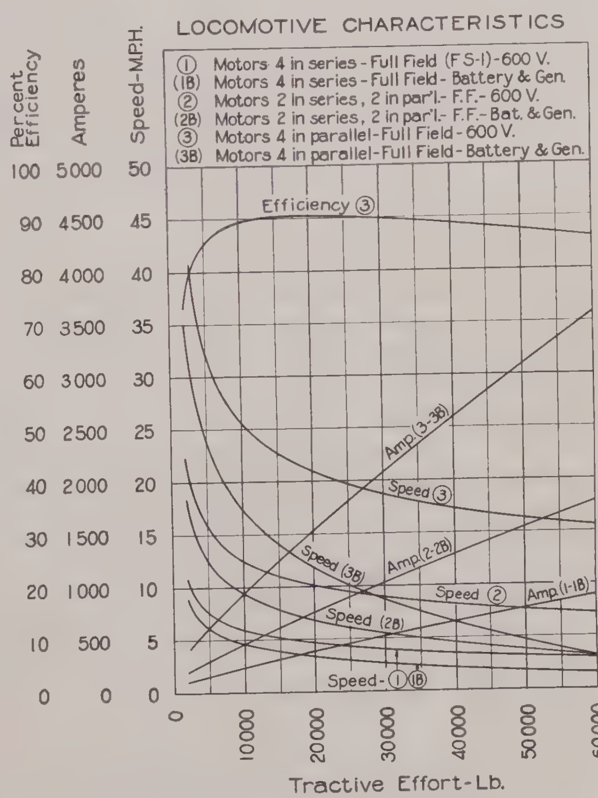

Fig. 2. Operating characteristics of New York Central three-power locomotive

curves are plotted from data taken during the tests on the initial New York Central locomotive. For the 300-hp. curve a number of points was obtained between 45- and 75-per cent operation, the curve being extended somewhat beyond these values upon reasonable assumptions. The 200-hp. engine curve is based largely upon assumptions since only one point (93 per cent) was available from the test data, this test being made by

setting the fuel finger of the oil engine governor to limit the engine output to 200 hp.

With a 300-hp. engine running 85 per cent of the time the battery discharge will be equivalent to approximately 15 per cent of the power delivered to the traction motors; therefore the maximum average work which the locomotive can do per eight-hour shift when operating three shifts per day on internal power is $114/0.15 = 760$ kw-hr. Using Fig. 1 and interpolating for the 250-hp. engine, it may be shown that a 250-hp. engine might have been used successfully with the 301-kw-hr. battery to meet the requirements of 500 kw-hr. per shift. However, it was thought advisable to allow some margin for contingencies; hence a combination of a 300-hp. engine with a 301-kw-hr. battery finally was chosen because of the greater margin of capacity per shift as well as the ability to use an oil engine which had been thoroughly proved in railway service. Characteristics of this locomotive on both external and internal power are shown in Fig. 2.

The oil engine finally chosen for both the New York Central and Lackawanna locomotives is the Ingersoll-Rand 300-hp. vertical, six-cylinder, four-stroke-cycle, trunk-piston, single-acting type with direct fuel injection. The engine is controlled by a constant-speed governor which regulates between 550 r.p.m., full load, and 575 r.p.m., no load. The engine is direct-connected through a flexible coupling to a six-pole, self-excited,

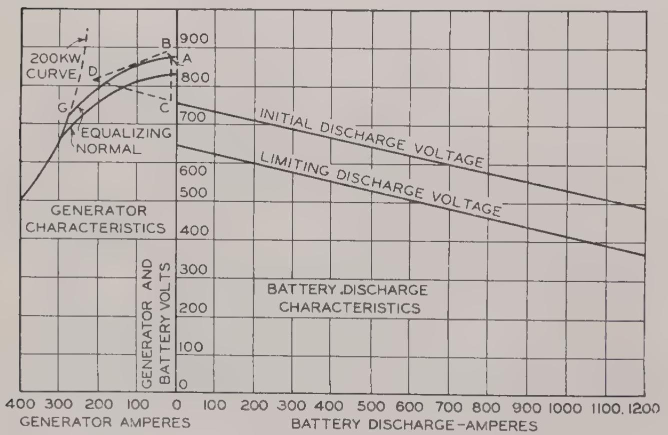

Fig. 3. Battery and generator characteristics of Lackawanna three-power locomotive

compound-wound, 200-kw. generator of the single-bearing type, with multiple self-ventilation.

Selection of Generator Characteristic

In Fig. 3 are shown the generator characteristics and the battery volt-ampere charge and discharge characteristics of the internal power plant of the Lackawanna locomotive. These characteristics are representative of general three-power locomotive practise. When the battery is fully charged, any rate of charge however small will produce gassing; if the charging rate be high enough, gassing will occur with the battery in any state of charge, although the rate may be reduced during the latter part of charge to a value which, unless abnormally sustained or occurring too frequently, will produce so small an amount of gassing as to be practically harmless. This value is called the *finishing rate* and is point B in Fig. 3. The charging rate at the end of the charge should be confined between the finishing rate and one-half of the finishing rate. Consequently, line AB represents the volt-ampere charge characteristic of the battery at finish of charge condition. The ability of the battery to absorb high charging rates at the start of charge is indicated by point D; this is the maximum charging rate recommended; hence, line CD is the volt-ampere charge characteristic at start of charge. Line DB represents the theoretical generator characteristic which would charge the battery in the minimum time, and AC that which would produce a constant current charge at one-half the finishing rate; therefore, the area $ABDC$ includes all values of current and voltage that may be used to charge this battery under permissible conditions, and the generator characteristic should intersect lines AB and CD and lie between lines BD and AC. The generator characteristic also is restricted by the 200-kw. output curve of the engine-generator set. To allow delivery of approximately full engine load over the whole range of battery discharge, the generator characteristic should pass near point G and lie close to the 200-kw. curve at voltages below G.

The higher generator curve in Fig. 3 meets these requirements and is suitable for giving the battery an equalizing charge, but is too high to permit the engine to run a sufficient percentage of the time to keep battery discharge within the daily limit of 125 per cent of rated capacity without overcharging. Therefore, the lower curve is used for normal charging and the higher characteristic for periodic equalizing charges.

When using the normal characteristic, the charging rate at the end of charge is less than one-half the finishing rate, but with a properly shaped characteristic and the engine running almost continuously, the battery will be maintained between equalizing charges in a satisfactory state somewhat below full charge. Use of the low generator curve for normal charging has the further advantage of allowing a margin for variation of characteristic between inspections, without the risk of overcharging the battery seriously, which might happen if the engine speed increased and the equalizing characteristic were being used in daily operation.

Control is arranged so that whenever the locomotive is operating on internal power and the traction motors are connected to the battery generator bus, the generator is transferred to the higher characteristic automatically. This is permissible because usually unless the battery is in a very low state of charge, the traction

motor load is sufficient to hold the generator voltage below the point where high charging rates will occur. This arrangement permits the use of a more drooping curve without dropping the traction power characteristic below point G. The necessity for a drooping curve may be appreciated better when it is considered that the battery is intended to deliver only 42 per cent of its capacity per eight-hour shift, whereas a generator characteristic lying along the line BD would give the battery a complete charge in four hours if applied continuously from full discharge and neglecting the small auxiliary load.

Fig. 4. Lackawanna three-power locomotive hauling a train on internal power

Over-all dimensions of locomotive

Length inside knuckles—48 ft. 0 in.
Total wheelbase—34 ft. 1 in.
Height over-all (pantograph locked down)—15 ft. 2 in.
Width over-all—9 ft. 11 in.
Maximum curvature—30 deg.
Truck centers—25 ft. 10 in.

Control of the Internal Power Plant

Both the New York Central and Lackawanna locomotives have a three-speed control on internal power. The series or lowest speed connection develops maximum tractive effort with minimum current from the battery generator unit, allowing most slow switching movements to be made almost entirely on the engine-generator set without using battery current.

On both locomotives transfer from external to internal power is controlled by a potential relay and is automatic upon loss of external power, although the automatic feature is selective on the New York Central locomotive because of power interruption on third rail gaps when transfer to internal power is not desired. Transfer from internal to external power is accomplished by turning the controller handle to the "off" position and then notching out, which is necessary because of going from a lower to a higher voltage power source. Indicating lights show whether operation is from internal or external power and whether collector shoes or pantograph are in contact with the third-rail or trolley wire.

The engine is started by motoring the generator from the battery through the starting resistance, the maximum field for starting being secured by short circuiting the generator shunt-field resistance. A reverse-current relay connects the generator to the battery when the proper generator voltage has built up; likewise it disconnects the generator should the generator voltage drop below that of the battery. To give the battery its weekly gassing charge the equalizing charge switch is closed, short circuiting a section of the generator shunt-field resistance.

Fuel oil is delivered to the engine through an electrically operated valve, which, should low lubricating oil pressure or overspeed occur, is closed automatically by means of an oil pressure switch or speed limit switch, respectively. The same rheostat values are used on both internal and external power on the New York Central locomotive. Control of the battery-generator combination is practically the same on both locomotives. On the Lackawanna locomotive, however, because of the great difference between internal and external power voltages, a set of contactors is employed to rearrange the resistor steps to secure proper operation on internal power.

Auxiliaries

Auxiliaries on the New York Central locomotive operate automatically from the third rail when available, but on the Lackawanna locomotive these run at all times on internal power, as this scheme is simpler and less expensive than furnishing auxiliaries for 3,000-volt operation.

Operating cabs are heated by hot water from the oil-engine cooling system. When working on external power, electric immersion heaters operating from the third-rail or overhead trolley are used to heat the cooling system water for cab heating as well as to prevent freezing.

Conclusion

The three-power locomotive has a field of its own and is not intended to supplant the straight oil- or gas-electric unit generally. The work of the locomotive when operating on internal power must be sufficiently intermittent to allow the battery to be maintained in a satisfactory state of charge. Heavy switching and short heavy transfer work on internal power or a combination of both, together with external power operation, offer conditions for which this type of locomotive is best suited. With its internal power feature, this locomotive approaches a universal locomotive for road freight, transfer, and switching service on sections of track which, for economic or practical reasons, could not be electrified completely.

Standardizing Sizes and Ratings

Marked economies may be secured by standardizing industrial products to eliminate all unnecessary sizes and ratings. Based upon a system of "preferred numbers," selection of desirable sizes may be made with reasonable accuracy through the use of algebra and geometry supplemented by judgment and common sense.

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CONSUMERS and producers of industrial products both are vitally interested in the most economical method of standardizing the sizes and ratings of such products. The consumers are interested because they bear every item of cost entering into both the manufacture and the use of an article; the producer because he will not be successful unless he can meet the requirements of the consumer in the most economical manner. In other words, the interests of the two in this respect are identical. If further it is realized that all of us are consumers of industrial products, and that the large majority of us are involved also in one way or another in production, it is evident that the subject is of very general interest and that an early and economically correct standardization of any type of product will prove of advantage to everybody.

However, in spite of the common interests of consumer and producer and the fact that most of us are both of these, a solution of this matter frequently is delayed because there are differences of opinion regarding the best choice of sizes or ratings. Such differences usually are due to the inclination on the part of most individuals to overemphasize those points which in the absence of proper methods of analysis happen to come closest to their attention. For instance, the consumer who is in need of a certain size of article usually hesitates to buy a standard article which is available but larger than he requires, because he feels that in so doing he spends more money than is necessary to meet his requirements. He therefore insists upon the size he needs and thus creates a demand for a large number of sizes. On the other hand, the producer who is put to great expense for tools, stock-keeping, etc., when there are too many standard sizes, frequently will overemphasize the importance of standardizing on as few sizes as possible. All this results in uncertainty and confusion when sizes are selected. Further difficulties arise from the fact that at first, each manufacturer usually establishes sizes and ratings more or less independently of other manufacturers of the same articles.

Later on, but generally not until a conglomeration of sizes has been established, standardization is attempted by those interested. Such efforts are then of course greatly handicapped by the clashing of individual interests, a condition which is unavoidable because of the investments made by the various manufacturers for tools and stocks. Even if a compromise is reached after considerable effort, it is usually at great expense to some or all of those concerned; and because it is agreed upon without due consideration of the best economic results continued waste may be involved in the compromise.

For the purpose of improving the situation just described, a system of "preferred numbers" has been proposed during recent years. Unfortunately so far little use has been made of it, partly perhaps because it has not been sufficiently promulgated, but probably more because industry and the engineering profession have not yet become thoroughly aroused to the fact that this problem of properly establishing sizes and ratings is deserving of most serious consideration. As their designation indicates, these preferred numbers, are certain numbers to be used in preference to any others in selecting standard sizes and ratings. They are arranged in so-called 5, 10, 20 and 40 series, each providing uniform steps between its numbers of 60, 25, 12, and 6 per cent, respectively. Naturally the general adoption of these numbers would be a great step forward, but even after their adoption there still remains the question as to which of the standard percentage steps is the most economical in any given case.

All this indicates a certain helplessness on the part of industry and the engineering profession in this matter of establishing sizes and ratings, and it most certainly emphasizes the desirability and necessity for a more analytical and rational manner of attack upon this important problem. It is the purpose of this article to deal with the fundamentals entering into the problem, and to show that a reasonably correct analysis is possible nearly always through the use of the simplest methods of algebra and geometry supplemented by good judgment and common sense.

Aggregate Size Manufactuered

The activity, or number of pieces required, of the various sizes of an article may be influenced by many factors, but usually it may be assumed to be fairly uniform, at least over a certain limited range. With this as a basis let us refer to Fig. 1 in which the hori-

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zontal scale indicates the sizes needed. Let it be assumed that over the range AB there are requirements for the sizes 1 to 7 as indicated. If there are no limitations imposed by tool costs, cost of stock-keeping, manufacturing set-ups, etc., upon the number of sizes which can be manufactured economically, there is no reason for not building the seven sizes just as they are needed. The sizes actually manufactured can then be represented by the straight line CD drawn at an angle of 45 deg. if the vertical scale indicates the sizes actually built. Practical cases of this kind are rare, but nevertheless they do exist. In most cases, however, because of the expense involved for development, tools, setting-up costs for tools, stock-keeping, and other similar factors, we find it necessary to limit ourselves to a reasonable number of definite standard sizes. The range AB shown in Fig. 1 might be covered, for instance, by three sizes, each of which might be assumed to be a certain percentage larger than the previous size.

In such a case the sizes actually built may be represented by the "step" curve *abcdefg*. It is evident at once that the aggregate size manufactured is in excess of that needed and that such excess is represented by the shaded triangles above the line CD. For any economic study it will be of value to know to what this excess amounts for various values of x which represents the ratio of the difference between the two sizes to the smaller size. This can be determined by a very simple calculation from Fig. 2, which reproduces one of the steps shown in Fig. 1. It readily is seen that the ratio of the excess size manufactured to the aggregate size needed is the ratio of the area of the triangle $c\,d\,e$ over the area of the trapezoid *klec*. This is found to be

$$S_e = \frac{x}{2 + x} \tag{1}$$

In Fig. 4 the upper curve marked $K_1 = 1$ has been derived from this equation and should prove useful for ready reference in economic studies of this kind. At times the activity decreases or increases with the size. Such cases can also be analyzed, but for brevity their treatment here is omitted.

Basic Aggregate Manufacturing Costs

In actual practise we are interested not merely in sizes, but usually even more so in costs. The latter may be studied by reference to Fig. 3, which shows in curve FG the relation of manufacturing costs to size for the range under consideration. Such a relationship is generally available from previous experience in the manufacture of similar articles or designs. Consider again a range kl as covered by one standard size and make an approximation by replacing the range me of curve FG by the dotted straight line ne; from the figure it is evident at once, that the ratio of the excess cost of the aggregate size manufactured to the cost of the aggregate size needed is the ratio of the area of the triangle *edn* to the trapezoid *klen*. This ratio is found to be

$$R_e = \frac{K_1 x}{2 + x\,(2 - K_1)} \tag{2}$$

The excess cost ratio for different values of K_1 (defined in Fig. 3) plotted against x as calculated from eq. 2 is shown in Fig. 4. In many practical cases in which other factors subsequently discussed are rather simple, suitable values for x can be readily determined from Fig. 4 by using proper judgment, especially when it is intended merely to choose between two values of x as given by the available preferred number series.

Consequential Costs as Depending Upon Size

A number of cost factors will be influenced by the fact that the aggregate size manufactured and used is larger than needed. First among these are the packing and shipping costs, which will be increased. Fre-

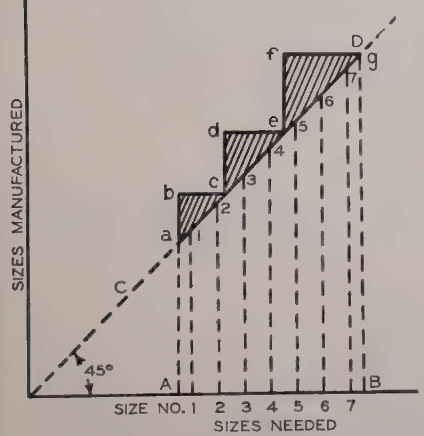

Fig. 1. Diagram illustrating standard sizes

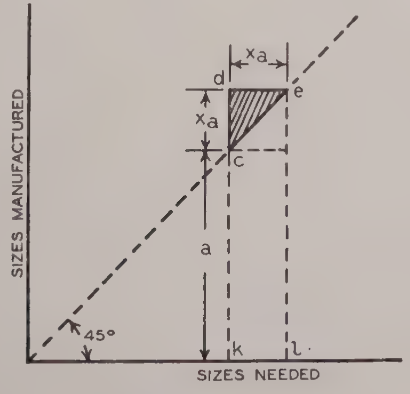

Fig. 2. Excess of manufactured sizes over sizes needed

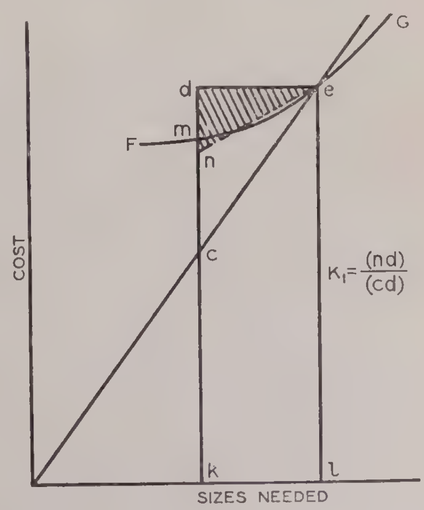

Fig. 3. Excess cost of manufactured sizes over cost of sizes needed

quently the fact that the part manufactured is larger than necessary also results in certain other parts of a design or combination being larger than necessary for the purpose. For example, if a bolt is larger than needed, the stock around this bolt and the cost for drilling and tapping also may have to be increased to some extent; again, if a pedestal bearing is larger than necessary, the bedplate supporting the pedestal will have to be made correspondingly larger. All these factors may be of varying importance even with the same type of article, depending upon the particular application. For this reason an average cost allowance will have to be made for a given range under consideration. These consequential costs will enter into some of the final calculations for the total cost, and can be taken into account simply by adding certain values to the manufacturing costs.

Engineering Development and Tool Costs

When a line of articles is developed, there usually are some portions of the cost for tools and development which depend upon the number of sizes manufactured; in other words, the cost of such tools and engineering and development work will be doubled if the number of sizes manufactured is doubled. Assume, then, that in Fig. 5 this part of the development and tool costs is represented by the curve GH in such a way that the ordinates at any one point give the development and tool cost for a size corresponding to such point. Thus the development cost D of the size le would be represented by lf. Further, it may be assumed that the total number of pieces to be manufactured during the life of the design over a given range AB of sizes is N. If this activity N is uniformly distributed over AB the total number of pieces over the range ax will be

$$N_x = \frac{N}{A\ B}\ a\,x \qquad (3)$$

According to previous consideration, the dotted line

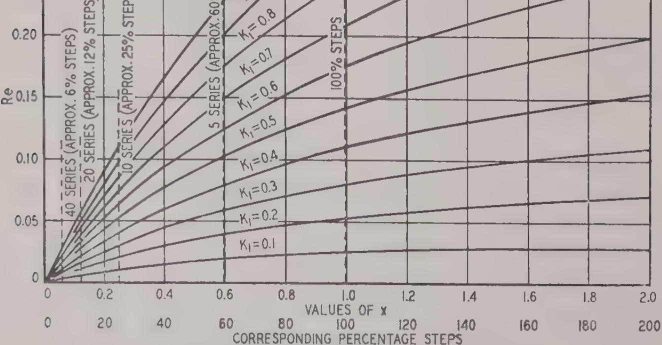

Fig. 4. Curves showing excess cost of manufactured sizes over basic cost of sizes needed

ne may be assumed to be proportional to the sum of the manufacturing costs and the consequential costs of the sizes as needed, so that the ordinate $le = b$ will represent the cost C of the size le.

The development cost D of size le can be evenly distributed over all the pieces N_x which are manufactured of that size during the life of the design. Therefore, the development cost per piece will be

$$C_d = \frac{D}{N_x} = \frac{D\,(A\,B)}{N\,a\,x} \qquad (4)$$

If C_d in Fig. 5 is entered in the proper scale, the shaded rectangular area may be considered as representing the aggregate development cost for the size le.

In addition to the development and tool costs so far considered, there are usually other costs for engineering, development, and tools, which are independent of the number of sizes manufactured. Examples of this are investigations relating to materials or methods, and similar fundamental developments. Another example is certain tool machinery which can and will be used in the manufacture of all sizes. Again, there may be some tools which will have considerable wear and which will have to be replaced repeatedly during the life of the design, so that their total cost will be governed by the total production rather than by the number of sizes. This also holds true when the production is so great that several sets of tools are needed regardless of the number of sizes. The costs of the tools just mentioned may be eliminated from our considerations.

Costs for Manufacturing Set-Ups

The manufacturing costs calculated under the heading "Basic Aggregate Manufacturing Costs" were assumed to be the basic costs and did not include any expense for the setting up of tools prior to actual manufacture. In practise it is usually necessary in changing from the manufacture of one size to another to change certain tools and make different set-ups which frequently involve appreciable expense. It is customary to manufacture at one time a number of pieces equivalent to the average consumption for a number of weeks or months. If such consumption or activity is N_s for the range of sizes AB, we find that the activity over the range ax for the same period of time is

$$N_{sx} = \frac{N_s}{A\,B}\ a\,x \qquad (5)$$

If the total of set-up costs involved when changing from one size to another is S we find the set-up costs per piece to be

$$C_s = \frac{S}{N_{sx}} = \frac{S}{N_s}\ \frac{A\,B}{a\,x} \qquad (6)$$

The previous calculations regarding set-up costs are made under the assumption that there is reasonably great activity for each size and that such sizes are manufactured for stock. There are certain cases of large

machinery, however, where practically every machine is manufactured as the order is received; thus a set-up cost is incurred for every order. If the set-up cost is independent of the size, it can be eliminated entirely from our calculations, but if it is dependent upon the size, it may be considered merely as part of the manufacturing cost and treated as such, as outlined under the heading "Basic Aggregate Manufacturing Costs." At times there may be cases between the two extremes just discussed which will necessitate calculations representing a combination of those outlined.

Cost of Stock Keeping

If the articles manufactured are marketed through a great number of small dealers, the total stock they carry and the expense incurred will be greatly influenced by the number of sizes. Assume that the average dealer feels that he has to have one or two pieces of each size, and possibly certain part stock for each size on hand at all times. He then incurs costs for invested capital, storage space, etc., proportional to the number of sizes carried. Similar costs may be incurred also because some of the stock will become obsolete before it can be disposed of, necessitating scrapping or selling at a loss. For calculations here it may be assumed that all of these costs incurred per size are represented by F. Assuming further that the activity over the range AB for the life of a given design is N_f the activity over the range ax will be

$$N_{fx} = \frac{N_f}{A\,B}\,a\,x \tag{7}$$

This means in turn that the stock-keeping cost to him for each piece is

$$C_f = \frac{F}{N_{fx}} = \frac{F}{N_f}\,\frac{A\,B}{a\,x} \tag{8}$$

If the manufacturer keeps only small stocks and the size of his stock is affected by the number of sizes, the same as just discussed for the dealer, the calculations are of course exactly the same. Similarly, the manufacturer's stock in district warehouses may be dependent upon the number of sizes.

In the case of a manufacturer dealing with large quantities, the total stock kept may be practically independent of the number of sizes manufactured. If such is the case, the cost for this stock-keeping may be eliminated from the considerations. This applies also to part stock which is common to all or to several sizes.

Cost of Spares and Stock in the User's Plant

When the user or purchaser of an article finds it necessary to keep a limited stock of each size, the considerations and calculations again are the same as immediately above. The same general principles apply regardless of whether this stock is kept for manufacturing purposes, as spares, or as spare parts for apparatus and machinery operated in the user's plant. One of the principal differences to the user from the costs immediately above may be a rather appreciable cost of spares because (on account of the importance of continuous operation) he may find it necessary to keep a complete spare machine in stock for each size when he has only one or two machines of each size in operation.

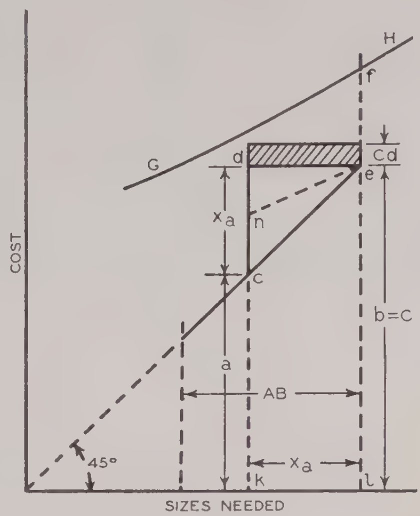

Fig. 5. Diagram illustrating cost of development and similar costs

As in previous cases, we can write the following equation

$$C_u = \frac{U}{N_{ux}} = \frac{U}{N_u}\,\frac{A\,B}{a\,x} \tag{9}$$

in which C_u is the cost to the user for his stock of spare material, N_u is the activity of the range AB, and N_{ux} the activity over the range ax.

Certain spare parts common to all or several sizes again may be neglected in this calculation.

Cost of Clerical and Routine Activities

In the manufacture and marketing of most articles there are a great many clerical and routine activities. When an article is first marketed, certain publications and price lists have to be issued. Any part of such expense which is dependent upon the number of sizes may be readily treated as part of the development cost. Certain routine in the works organization, such as the entering of orders, might be considered as part of the set-up cost, while other clerical activities in connection with stock-keeping of course may be combined with the cost of stock-keeping. Then again there may be other routine activities of a different nature which cannot be made a part of any of the costs previously treated, but which in nearly all cases may be taken care of in a very similar manner and by formulas corresponding to those given. Any such clerical or routine activities which are independent of the number of sizes may be omitted from considerations.

Total First Cost

As indicated previously interest is focused chiefly on those costs which are dependent upon the number of sizes. Some of these as indicated by eq. 2 increase with a decreasing number of sizes. While this equation was derived for the basic manufacturing costs, it is equally correct if the cost curve *FG* in Fig. 3 is assumed to include the costs discussed under the heading "Consequential Costs as Depending on Size" as well as certain costs indicated in the last paragraph under "Costs for Manufacturing Set-Ups." Most of the other costs discussed decrease with decreasing number of sizes.

It is now merely a question of carrying through the development of a formula giving the sum of all costs and finding the ratio R of the total cost to the basic manufacturing cost C_n incurred if each size were manufactured as needed. The value found for R is

$$R = \frac{C_t}{C_n}$$

$$= \left(1 + K_1 \frac{x}{2 + x(2 - K_1)}\right)\left(1 + K_3 \frac{1 + x}{x}\right) \quad (10)$$

where

$$K_3 = \frac{1}{C} \frac{AB}{b}\left(\frac{D}{N} + \frac{S}{N_s} + \frac{F}{N_f} + \frac{U}{N_u} + \ldots\right) \quad (11)$$

and

C = the cost previously defined in connection with eqs. 3 and 4, but including where necessary an allowance for costs as discussed in the last paragraph under "Costs for Manufacturing Set-Ups."

We thus have a fairly simple and complete formula from which it is possible to calculate the total first cost for various values of x assuming, of course, that there are at least approximate basic data available from which K_1 and K_3 can be determined. A typical curve calculated from these formulas is given in Fig. 6. From it can be determined the relation of excess costs over basic manufacturing costs for different steps between sizes.

Utility, Serviceability, and Performance

Consideration of utility, serviceability, and performance has been left for discussion until now not so much because it is of less importance than the previous items, but because in many cases these three items cannot be made the subject of exact calculation. Their influence therefore often has to be determined by judgment with the aid of such curves as shown in Fig. 6. This will be shown in a number of examples.

Frequently the utility of an article is greatly increased if it completely fills a given space. For example, often it may be desired to use as large a kitchen range as possible within the space available. In view of this it is obvious that a line of ranges inclusive of many sizes will have greater general utility than a similar line composed of fewer sizes. Assume that in a case of this kind the cost curve of Fig. 6 applies, giving a minimum first cost for $x = 0.4$. It is evident at once that on account of the utility feature, the 10 series of preferred numbers, giving 25 per cent steps and corresponding to $x = 0.25$,

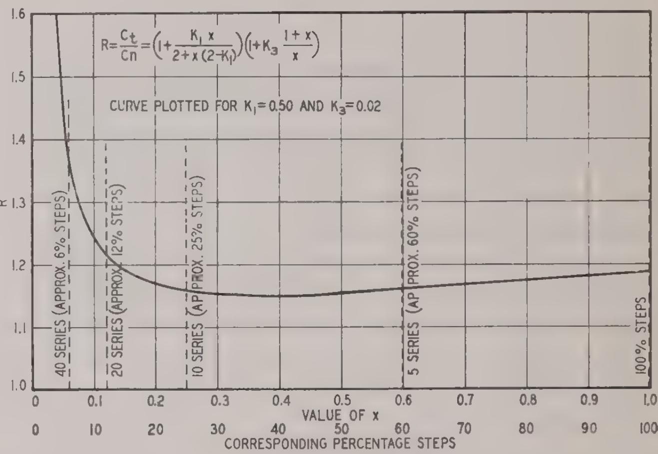

Fig. 6. An example illustrating ratio of total cost to basic cost as related to size of step used

should be chosen in preference to the 5 series with 60 per cent steps and $x = 0.6$. Even the 20 series, with $x = 0.12$ and an increased first cost of 6 per cent, might be considered. On the other hand, it is more or less evident that since the 40 series would increase the first cost as much as 20 per cent, probably the choice of it would make the manufacturer covering such a large number of sizes non-competitive.

In the case of machinery the question of efficiency or other factors of performance have to be considered. This then may necessitate an engineering study of such factors, and as a result of such study, it may be concluded that the steps considerably smaller than indicated by the curve shown in Fig. 6 should be chosen.

In previous examples the utility and performance considerations tend toward the use of more steps than indicated by the cost curves. An example of the opposite kind would be where the wear and tear of apparatus is of great importance. If but few steps are available, the installed apparatus in many cases will be used below its full rating, which will frequently reduce the average wear. In a case of this kind the use of the 5 series might be resorted to with the cost conditions of Fig. 6, indicating for the 5 series an increased first cost of only 1 per cent over the minimum.

Other instances where the utility favors the use of larger steps are those of machinery where there is a likelihood of the load increasing as time goes on. If in

such cases few steps are used and if as a consequence many of the applications are underloaded to begin with, the necessity for installing new and larger machines will be minimized. Another factor which is frequently of importance with regard to the utility of an article is its interchangeability with other similar articles. The possibilities for such interchangeability are better of course with fewer sizes, and therefore with cost conditions as indicated in Fig. 6, this consideration might lead to the choice of the 5 series in preference to the 10 series.

Even when several of the previous factors have to be taken into account, the proper choice of x usually does not present great difficulties after curves as given in Fig. 6 are available.

Miscellaneous Factors

A number of miscellaneous factors may enter into the picture. Assume, for instance, that a new type of apparatus is being developed and that there are uncertainties regarding the design and various commercial factors, all of which may bring about changes in the design sooner than contemplated. If in such a case Fig. 6 indicates the cost condition, it would seem to be good judgment to start with the 5 series, with plans for filling in later on to obtain the 10 series after experience has been acquired.

In actual practise, too few sizes may entail extra expenses which cannot be included readily in the cost calculations as previously given. If, for example, shafts of various sizes are machined from the round stock, the cost of machining many of the shaft sizes will be increased if the number of stock sizes of the raw material is decreased. If Fig. 6 is assumed to apply to a cost study of this kind and the extra cost of machining has not been included in the calculation, it at once is evident that the 20 series is likely to be the best choice. Of course the manufacturer cannot ignore completely his own commercial situation; for example, it is evident that a manufacturer having a greater number of sizes available, is likely to secure a larger proportion of business than one having fewer sizes. This in itself might be a deciding factor in favor of choosing the 20 series in preference to the 5 or 10 series in a case covered by the curve of Fig. 6.

Preferred Numbers

In the foregoing, repeated reference has been made to "preferred numbers" and it has been taken for granted in the examples cited that in every case one of the standard series should be chosen. While such curves as shown in Fig. 6 may indicate a minimum for values of x, which are different from those corresponding to one of the preferred series, it fortunately is true that near the minimum these curves are rather flat. This means that after considering some of the utility features or similar factors, it nearly always is possible, as indicated by the examples given, to choose one of the standard series to good advantage. There may be exceptional cases where for some reason or other this is not advisable or possible. Thus it may happen that the most economical conditions can be obtained with steps much larger than the 60 per cent steps of the 5 series. For such a case, 100 per cent steps can be readily obtained by using every third step of the 10 series; or 150 per cent steps will result from the use of every second step of the 5 series. In fact, nearly every condition encountered in practise can be taken care of by using some combination of figures chosen from the preferred-number series.

In the space here available it has been impossible to treat all the conditions which may be encountered in the great variety of industrial products; each case will be somewhat different and therefore various methods of attack will have to be used. The principal purpose of this brief outline is to stimulate interest in this important subject of standardizing sizes and ratings. The fundamentals discussed are intended merely to assist in a more rational solution of the problems. If they are judiciously applied, together with an increased adoption of preferred numbers, marked economies to both the consumer and the producer of industrial products undoubtedly will result.

Cooperative Instruction in Engineering Schools

ALTHOUGH the cooperative method of instruction is assured a permanent place in engineering education, cooperative courses in general still are considered to be in an experimental state of development. In a current A.I.E.E. paper (see footnote) by D. C. Jackson, Jr. (F'30) of the University of Kansas, some well known factors controlling the establishment of this plan of education are reviewed as are some of the general methods of applying it to various types of institutions.

While the author states that "no exact conclusions can be drawn concerning the general principles governing the installation of the cooperative method," he expresses the belief that it is not *universally* applicable to engineering schools and polytechnic institutes; nor is there any one *best* method of using it.

Abstracted from "Application of the Cooperative Method of Instruction to Engineering Schools and Polytechnic Institutes" (**No. 31-113**) by D. C. Jackson, Jr., presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

Steam vs. Electricity for Driving Power Station Auxiliaries

During the past few years important changes effected in power station and system design have reduced operating expenses materially. At present, however, station designers are giving more attention to the reducing of investment costs. This reduction of plant investment quite naturally affects the plant auxiliaries as well as other station equipment. Many large stations built recently have practically all of the essential as well as the non-essential auxiliaries driven by electricity; but in other recent stations steam driven auxiliaries have been used quite extensively. In the light of present conditions and past operating experience, therefore, the A.I.E.E. power generation committee felt that a review of the characteristics and merits of both steam and electric drives would be in order. Accordingly, this committee has sponsored three papers to be presented at the Institute's forthcoming winter convention, and upon these papers the following three articles are based.

I—Importance of Reliable Auxiliaries

By
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A WELL DESERVED reputation for continuity of service is enjoyed by the electric service industry as a whole. The public has become accustomed to receiving continuous service; furthermore, the large investments of the power station companies and of their industrial customers demand an uninterrupted supply of energy. One of the most important factors vitally affecting continuity of power service is the reliability of generating station auxiliary equipment. Reliability therefore well deserves all the careful attention that has been devoted to it in these articles.

The valuation of variable speed auxiliaries makes an interesting study in the application of auxiliary drive. In the past, station designers have used variable speed drives for fans, pulverizer mills, boiler feed pumps, and circulating pumps quite extensively. However, recent developments in the manufacture of auxiliary equipment and station design have made variable speeds less necessary, the one exception to this trend being boiler feed pumps for high pressure boilers. The article on steam driven auxiliaries (Dryer) brings out very clearly the advantages of the steam turbine as a simple and efficient means for obtaining variable speed drive.

Another important point brought out in these articles is that the type of drive best suited to essential auxiliaries such as fans, boiler feed pumps, and circulating pumps, is related closely to, and dependent upon, the general design of the station. Station design in turn is influenced by the relation of the station to the balance of the power system with respect to interconnections, size, and location. For instance, a power station that forms the chief source of supply for an area, and that does not have reliable interconnections with other power systems, quite apparently warrants more reserve equipment and must have a greater number of steam driven auxiliaries for starting up purposes than a station forming a part of an interconnected system. Furthermore, a new power station forming a part of a large interconnected group may be designed and built to operate at a better load factor than a comparatively isolated station thereby reducing the need for variable speed auxiliary drives.

Selection of an auxiliary drive is affected also by the kind of fuel and fuel burning equipment used, as well as by station space limitations. Gas- and oil-fired boilers as well as those burning pulverized fuel are somewhat more flexible than stoker fired boilers and therefore can be taken out of service more readily with changes in load. This favors the use of constant speed electric drive. On the other hand, where the bin system of pulverized fuel supply is used, exhaust steam usually is required to dry out the coal, thus justifying the use of some steam driven auxiliaries. In addition, if ground

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Based upon "Auxiliary Drive for Steam Power Stations" (**No. 32-46**) to be presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

and building costs are high and variable speed is required, the use of steam driven auxiliaries may result in an appreciable saving.

It is interesting to note that the total auxiliary power used by a modern station is a relatively small part of the gross generated power, being approximately from 4.5 to 6 per cent; hence a radical saving in auxiliary power cannot be expected from any type of drive. Likewise, the investment cost in auxiliary power including drive and control equipments is a relatively small part of the total station cost, being in the case cited for electric drive (Smith) approximately 7 per cent of the total station cost. Apparently station designers are more or less free to use either type of drive without seriously affecting either the cost or the efficiency of a power station as a whole. Electric drive is favored for essential auxiliaries from the standpoint of convenience and cleanliness in operation, and also because it is more readily adapted to automatic and remote control, particularly in the boiler room.

As regards maintenance costs, a comparison between steam and electric drive would be of interest; however, representative figures are difficult to obtain, chiefly because sufficient time has not elapsed since the more modern stations were placed in operation. In addition, during the last few years the advancement in station design has been so rapid that it is difficult to find stations of sufficient similarity to make a fair comparison.

In passing to the other two articles of the group it may be said that the treatment is inherently one of generalities because of the many factors that may enter into the selection of an auxiliary drive. Discussion of the subject matter, however, should be of interest in bringing out points for consideration when determining the type of drive best suited for any specific application.

II—Steam Driven Plant Auxiliaries

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RELIABILITY may be set down as the most outstanding requirement of electric power station auxiliaries since, among other things, an uninterrupted supply of power depends upon the ability of the *essential* auxiliaries to function continuously. Thus any arrangements made for guaranteeing the operation of these auxiliaries should be appropriate to the degree of service reliability expected from the station. These arrangements for station auxiliaries involve the furnishing of a reliable supply of energy as well as turbines, motors, and accessory equipment which are free from physical defects and which possess suitable operating characteristics. Considerations secondary to this first requirement of reliability are simplicity, initial cost, maintenance expense, and economy of power.

For greatest reliability, essential auxiliary driving units must be supplied with energy free from disturbances which would interrupt their operation. To the extent that the source of supply is exposed to those disturbances, arrangements must be made to limit the effect of any single disturbance to as few auxiliaries as possible, and to provide a duplicate source immediately available should the primary source fail. Minor disturbances such as slight reductions in steam pressure or voltage are to be expected and provision against them should be included in the design of the drives. The question which naturally arises then is "to what extent is the provision of a duplicate source of supply advisable when the essential auxiliaries are steam driven; and to what extent when motor driven?"

Reliability of Auxiliary Steam Power

Disturbances threatening interruption of the auxiliary service may originate either within or without the station. In properly designed and operated stations with turbine driven auxiliaries, no external circumstances can disturb the characteristics of the steam supply to an extent which will prevent the auxiliaries from always having available sufficient driving power of suitable characteristics. If not anticipated and arranged for, one circumstance which could interfere with the ability of the steam power to sustain the proper operation of auxiliaries would be the sudden imposition of an abnormally large electrical load on the station. By overtaxing the evaporating ability of the boilers, the pressure in the steam system might be lowered to the point at which some essential auxiliaries would "lie down." The station then would fail to deliver not only its additional load requirements but also its original load. With this contingency recognized in the modern station, and provided for by holding banked boilers in reserve, by accepting load at a rate appropriate to the steaming ability of the boilers, the operation of steam driven auxiliary equipment remains immune to external disturbances.

Troubles originating within the station and affecting the steam supply to the auxiliaries enough to prevent their operation could be caused only by conditions resulting in an excessive lowering of the steam pressure at the throttles of the auxiliary turbines. Under such conditions, certain types of pulverized fuel mills which require a substantially constant torque regardless of output would stop. This might result in the boilers,

Based upon "Steam Driven Auxiliaries for Power Plants" (No. 32-3) presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

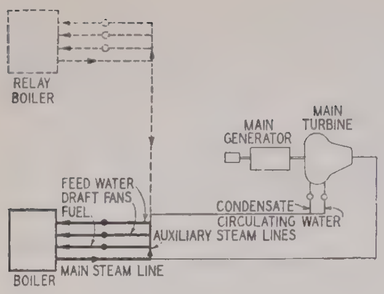
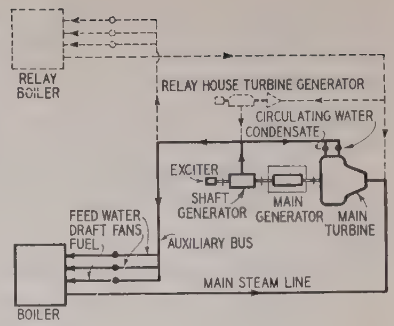


Fig. 1. Energy diagram for a station generator unit with all essential auxiliaries steam driven

Fig. 2. Energy diagram for station generator with all essential auxiliaries electrically driven



Heavy lines indicate auxiliary equipment and lines which must function continuously to prevent interruptions

being inadequately supplied with fuel, failing to sustain steam pressure. Such excessive decrease of steam pressure, however, is preventable and never encountered in stations properly designed and operated.

Reliability of Auxiliary Electric Power

So far as the supply of energy is concerned, a station with electrically driven auxiliaries supplied from a single energy source would not be as reliable as the station with turbine driven auxiliaries. Once the steam energy destined for auxiliaries is transmuted into electrical energy for use in motors, it enters an additional realm wherein its stability is both more sensitive to disturbance and more subject to unexpected attack. Hence, to attain the same degree of reliability as in the station with turbine driven auxiliaries, the station with motor driven units must have duplicate sources of energy.

Since service from the auxiliaries must possess a higher degree of reliability than the main electric power supply, the auxiliaries must be supplied with energy from at least one source not connected to the main generator or to the outgoing lines. This entails furnishing for the auxiliaries at least one generator which may be driven by either the main turbine or by a turbine introduced solely for this special purpose. In important cases, two special generators are used, one driven by each of these turbines. This is done frequently in "downtown" stations of metropolitan systems, where it is considered essential to keep the auxiliary system always free from the effects of external disturbances.

Not only is it necessary to provide special generators and sometimes duplicate distributing systems in stations with motor operated auxiliaries, but it is customary for such important auxiliaries as boiler feed pumps and exciters to rely upon turbines as an ultimate resource.

Reliability of Turbines and Motors

The ultimate reliability of any auxiliary equipment is the compound reliability of its power supply and of the performing abilities inherent in the apparatus itself. Regarding the inherent structural qualities of auxiliary turbines, these machines in their main parts are sturdy, and, as a concession to low initial cost, simple and inefficient compared to the main turbine units. Their parts most questioned are the reduction gears, governors, and valve mechanisms. However, the art of gear-cutting now has been developed so that gears seldom give trouble without ample warning. Governors and valve mechanisms are less certain in operation unless particular skill is applied to their design.

As a basis for evaluating the degree of structural reliability of turbines, they may be compared with the more usual types of motors: the squirrel cage, and the adjustable-speed wound-rotor types. The simplicity of the construction of squirrel cage motors and their accessories probably place them in approximately the same grade of inherent reliability as turbines. Wound rotor motors and their accessories, however, involve parts and constructions which may be preferred only through consideration of power economy. Thus, regarding inherent qualities, it might be said fairly that in the case of constant speed equipment, steam driven auxiliaries are as reliable as those electrically driven; and in the case of variable speed equipment, they are more reliable.

A further aspect of inherent performance reliability in the driving apparatus itself is the relative ability of turbines and motors to drive variable speed equipment smoothly and without transitional disturbances, particularly draft fans. On such duty, the turbine, with its infinite number of speeds, performs evenly. The wound rotor motor, with its step action transition in speeds, is more likely to cause disturbance in burner flames; and further operating complications are encountered in changing from the motor of one speed to that of another.

Relative Efficiency of Turbine and Motor Drives

Despite their reliability and simplicity, turbine driven auxiliaries were displaced to a large extent when it was discovered that a fuel saving could be made if steam for producing auxiliary power first was passed through efficient main turbine units to produce electric energy, and then extracted for water heating, instead of being passed through small inefficient turbines driving auxiliaries mechanically and then into feed water heaters. The fundamental reason for this gain in economy is that the surplus energy thus made available is produced much more economically than the rest of the station output energy because the steam required for

generating this surplus energy extracted is for heating the boiler feed water. As a result, this steam is utilized at a station thermal efficiency of between 90 and 100 per cent, whereas the steam used for generating the rest of the output energy is carried into the condenser, where most of its original heat energy is lost, and so is used at an efficiency between 20 and 35 per cent.

With regard to the economy actually effected by these changes the examples illustrated in Figs. 3 and 4 show that by substituting motors for turbines on all essential auxiliaries, and by heating the feed water with extracted steam instead of auxiliary exhaust steam a modern station's net output for a given fuel consumption is increased at maximum load about 1.75 per cent; the over-all thermal efficiency of the turbine-driven auxiliary station is 24.4 per cent; for a station with motor drive it would be 24.8 per cent. In this comparison other conditions have been kept similar. It may be observed that in Fig. 3 less steam is needed for water heating than in Fig. 4. This is because the auxiliary turbine in Fig. 3 is inefficient. As a result, hot steam is exhausted, less of which is required for feed water heating than is needed of the cooler steam extracted from the efficient main turbine; however, the greater the percentage of the total steam in the main turbine which can be extracted and used for heating, the smaller the remainder to go into the condenser and the greater the net station output for the same fuel consumption.

Not as a principle unique to either turbine or motor drives, but as one common to both, it should be realized that the station efficiencies shown in Figs. 3 and 4 could and should be increased by heating the feed water further than is shown in these examples by extracting steam from one or two high temperature points of the main turbine. Moreover the 1.75 per cent advantage attained in the station shown in Fig. 4 would have been slightly greater if, instead of using one point of extraction, two had been employed to heat the water to the same temperature; and due alone to the stray losses encountered in actual operation, advantage in favor of electric drive might be as high as 2.5 per cent.

Difference between the efficiencies of the two stations compared would have been very much less if the high efficiencies now obtainable in auxiliary turbines had been assumed instead of the low efficiencies actually taken as better representing common practise. Also, it should be understood that the relative efficiencies of the two stations were estimated for only one station load; with both stations operating at their maximum output, and the auxiliary turbines and motors performing at their maximum loads, and hence at their optimum efficiencies.

Power Consumption

To ascertain the total difference in power consumption between steam and electric driven auxiliaries over the whole working range of the boilers and turbine generators, and hence the net annual saving in fuel, requires a determination of the power taken at partial loads by both types of drives. This was done by analyzing separately the power input to each essential auxiliary when driven by turbines, squirrel cage, and adjustable-speed wound-rotor motors. In the analyses based upon power output of the boiler, that output was reckoned as the power which the main turbine generator would produce with the quantity and quality of steam delivered by the boiler at its different loads. The power consumed by the turbine driven auxiliaries in all cases was calculated as the power which the quantity of steam used in these auxiliaries would have produced if used instead in the main turbine generators. These analyses represent the performance of equipment in stations having large boilers and turbine generators, where the auxiliary turbines also would be large and slightly more efficient than those often used. However, turbines having higher efficiencies than those assumed in this analysis are now in operation on auxiliary service.

Results of these analyses showed that:

1. For such auxiliaries as circulating water pumps and fuel pulverizing equipment, where the output is substantially constant throughout a wide range of load on the main units, and for which constant speed squirrel cage motors are suitable, the electric drive maintains throughout the entire load range its relative efficiency over the turbine drive.

2. For auxiliaries such as boiler feed pumps and draft fans, in which the output varies with the load on the main units, the squirrel cage motor rapidly loses advantage in the power saving which electric drive gives at maximum load; below approximately 85 per cent load on the main units it is less efficient than the turbine. At lower loads, the initial relationship between the two drives can be reestablished by transferring the load to a lower speed motor, but upon reducing the load still further, this motor will in turn become less efficient than the single turbine.

3. The superior economy which the adjustable-speed wound-rotor motor gives at maximum load over turbine drive diminishes greatly as the load decreases and vanishes at small loads unless operation is transferred to an additional lower speed motor.

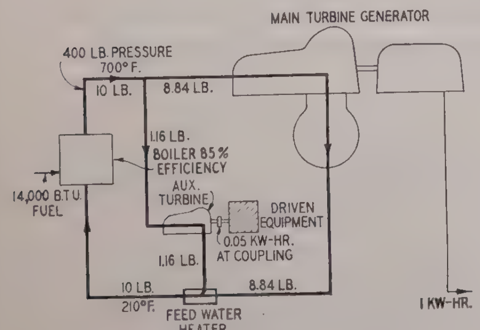


Fig. 3. Station efficiency diagram with all auxiliaries steam driven

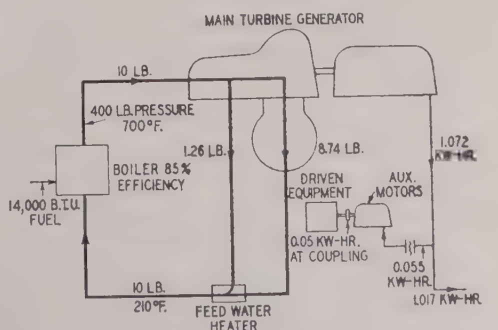


Fig. 4. Station efficiency diagram with all auxiliaries electrically driven

Relative Operating Costs

Conclusions just outlined indicate that from considerations of power consumption, the most favorable application for turbine drive is on equipment like draft fans which, having to traverse a wide range of speed and load, use more than one motor when electrically driven. Even on this application the electric drive saves power; but it involves a larger investment in both driving and generating equipment. Regarding the investment in driving equipment, it is estimated that for large boilers having a maximum output of the order of 500,000 lb. of steam per hour and with two wound rotor motors per fan, the installed cost of motors, controllers, and wiring for both forced and induced draft fans would be about $10 per rated fan horsepower more than for turbines with their valves and piping.

Regarding the investment in generating equipment assessable against the fan drives, if the fans are electrically driven, and all equipment usually provided for normal and emergency supply assessed, the turbine room cost will be found to increase about $49 per installed fan horsepower. If the draft fans are steam driven, 0.7 per cent more total evaporating capacity is needed than if motor driven; as a result the boiler room in this case costs about $12 more per installed horsepower than in the other case. Those investment costs are based on a total station cost of $95 per kw. output.

On the basis of the foregoing, the total investment incident to the electric drive for fans will be $37 higher per installed fan horsepower than for the turbine drive. If the annual charges on this higher investment is less than the cost of fuel per installed horsepower saved by the electric drive, then motors would be more economical than turbines, and *vice versa*. Seldom, however, would motors be more economical. Even with coal at $4 per ton and a capacity use factor of 100 per cent, the combined fuel cost and fixed charges would be less for the turbine drive than for the motor drive. In plants designed to deliver large quantities of steam for industrial uses or for heating, the economic balance is usually in favor of turbine drive regardless of load factor and fuel cost.

Future Developments

To realize fully the advantages obtainable by using auxiliary turbines in conjunction with large main units, more efficient designs and methods of application become desirable, practicable, and commercially feasible. With the conventional designs and applications of these machines, more stages and larger diameters can be used to raise the efficiency at maximum load; however, care must be taken that the gain is not so obtained at the expense of inefficient partial-load operation.

Novel means for securing high efficiency have been adopted in turbines recently installed in one particular large central station; there, not only high rotative speeds and many stages of highly refined design have been introduced, but the steam is passed in series through two turbines. For stations of high steam pressure (600 lb. per sq. in. and more) still other means may be evoked to improve the efficiency of auxiliary turbine operation, as indicated in Fig. 5. Here the improvement is derived through using machines of conventional design, but with novel steam connections. These features contribute to low initial cost of machines and piping, and low maintenance; but much care and some ingenuity of design is required to protect operating

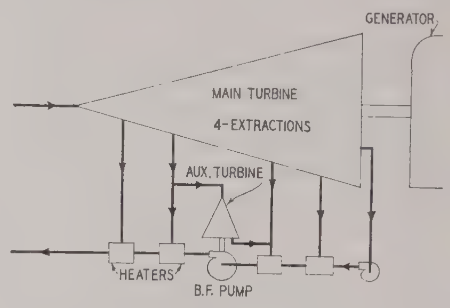


Fig. 5. Steam and exhaust connections for auxiliary turbines in a typical high pressure station

continuity while preserving simplicity of design and avoiding undue piping complications.

In regards to turbine gearing, this accessory usually performs quietly and satisfactorily. It is desirable, however, that still more attention be given to its design and manufacture so as to remove completely the objection to turbine auxiliaries still offered in some quarters where objectional gear noise has been experienced.

While it is indicated that the immediate development of the auxiliary turbine will be along the lines of higher efficiency and greater refinement in mechanical detail, the development of electric drive should be directed toward greater simplicity and lower installation cost. Greater sturdiness of variable speed motors is desirable as is also wider speed ranges; but the greater field for improvement is in distributing systems and control equipment. It is desirable to retain the efficiency and convenience of motor drives without sacrificing reliability, but at substantially lower cost. At the moment just how this end may be accomplished is not clear; but the problem is receiving the attention it deserves, and the great variety of systems adopted in stations built recently indicates that plant designers are far from satisfied with conventional systems and are striving to produce something better.

Conclusions

Noteworthy conclusions brought out by the foregoing discussion are summarized briefly in the following paragraphs:

1. At present the turbine constitutes the simplest and most reliable drive for steam power station auxiliaries. For applications requiring extreme protective measures, the simplicity and reliability of turbine drive may warrant its selection for all essential auxiliaries.

2. For maximum load conditions an improvement in over-all fuel economy of the order of 2 per cent will result incidental to the use of motor drive instead of turbine drive for all essential auxiliaries; with both drives, steam would be extracted from the main turbine for feed water heating, more being drawn where motor drive is used.

3. For constant-speed auxiliaries the economy due to motor drive is greater at partial loads than at maximum load.

4. For variable-speed auxiliaries the advantage in economy with motor drive is slight at small loads.

5. Under most conditions the total annual expense for draft fans and perhaps for boiler feed pumps, including fuel costs, maintenance, and capital charges, will be less with turbine drive than with motor drive.

6. There is an element of convenience in the starting and stopping of motor drive which commends it to the average operator, other considerations being approximately equal.

7. The use of turbine drive is not justified for non-essential auxiliaries (which may stop for a short time without inconvenience) these ordinarily being driven at constant speed.

8. Future developments may change the relative status of two drives; but indications are that in the immediate future progress will tend to decrease the advantage in fuel economy which the motor now possesses, and to increase the turbine's advantage of reliability.

III—Electric Drive for Plant Auxiliaries

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A REVIEW of the history of auxiliaries for steam power stations shows a gradual change from complete steam drive to the other extreme of complete electric drive, except for a few reserve steam driven auxiliaries such as boiler feed pumps and service pumps. During an intermediate period, dual steam and electric drive was used quite extensively for some of the essential auxiliaries, but the number of dual drives appears to be diminishing steadily.

Higher efficiency of electrically driven auxiliaries receiving their power from the efficient main turbine or house turbine, as opposed to small inefficient turbine driven auxiliaries, always has been attractive to the station designer. However, lack of confidence in the reliability of the early forms of electric drive for essential auxiliaries retarded its general adoption until more operating experience was obtained and reasons other than greater efficiency appeared.

The change from steam to electric drive is due largely to an increasing feeling of confidence in the reliability of electric drive, an increasing appreciation of the simplicity and flexibility of electric drive, and important changes in boiler and turbine practise. Confidence in electric drive has been strengthened by improvement in the manufacture and application of electrical equipment, the proved value of station and system interconnections, and a record of successful operating experience. The convenience and flexibility of electric drive are known generally, but will be discussed more in detail later. Important changes in boiler and turbine practise that have influenced the use of electric drive are multi-stage bleeding of turbines for feed water heating, the use of higher steam pressures and temperatures, the development of larger boilers and turbines with their multiplicity of similar auxiliaries, and, to some extent, automatic combustion control.

Based upon "Electrically Driven Auxiliaries for Steam Power Stations" (**No. 32-6**) to be presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

Comparative Reliability of Steam and Electric Drive

Reliability always has been considered the chief requirement for essential auxiliaries; steam is considered more reliable than electric drive chiefly because it is a more direct method of obtaining power. Electric drive introduces additional apparatus such as generators, transformers, and switching and control equipment between the boilers and the auxiliary to be driven. If the electric auxiliary is connected directly or indirectly to the main bus, it is exposed also to the effects of line disturbances. Performance of the intermediary equipment required for electric drive now will be considered from the viewpoint of reliability.

Main and house turbines probably are more reliable than efficient auxiliary turbines; furthermore, the larger units receive much closer attention than could be given economically to auxiliary turbines. Concerning the generators, statistics show that failures are extremely rare, especially since closed ventilation systems have been used; but in case failure of the main generator should occur, there is usually no immediate need for the auxiliaries associated with either the generator or the boilers. Auxiliary transformers have an equally good record for freedom from trouble. Modern switching and control equipment too in recent years has given but relatively little trouble, especially when selected and installed with the usual liberal safety factors.

A large proportion of the motors used for electric drive is of the squirrel-cage induction type which is unusually sturdy, and which readily permits full voltage starting with its inherent simplicity of control. However, when correctly applied and maintained, other types of motors also have given good service. Furthermore, improvements in insulation and bearings have made motor coil failures rare.

In regard to the reliability of power supply for electric auxiliaries, the extensive use of bus and feeder reactors, and diversity of power feeds, have tended to minimize the effects of line disturbances. The present trend toward faster operation in oil circuit breakers also

will minimize the effects of line disturbances. From these facts it seems apparent therefore that reliable service may be expected from electric drive when applied correctly.

Simplicity and Flexibility of Electric Drive

It is difficult to conceive of a simpler drive for rotating equipment than the squirrel-cage motor. Perhaps, however, the greatest advantage in simplicity of the electric motor versus the steam turbine lies in the method of control. A motor for instance may be started and stopped in a fraction of a minute simply by pushing the button, whereas the ordinary small auxiliary turbine usually requires a preliminary warming up. Besides these advantages the convenient control of auxiliaries from a few centralized points, made possible by electric motor drive, often permits a reduction in the station operating staff and contributes toward better efficiency of operation.

Flexibility likewise is an important factor in auxiliary equipment especially from the viewpoint of station design. Here again the almost unlimited flexibility of electric drive gives it a great advantage over steam, as evidenced by modern boiler combustion control systems. The absence of steam piping to the turbine and boiler room auxiliaries, made possible by electric operation results in less congested basements and thereby facilitates station design, operation, and maintenance. Furthermore, in obtaining the station heat balance electric drive provides greater flexibility than steam.

Modern Trends in Station Design Favor Electric Drive

Selection of the type of drive for a station's auxiliaries usually is not made entirely on the basis of the relative performance of motors and turbines, but is determined to a large extent by the general design of the station. One of the most important changes in station design and one which has tended to increase the use of electrically driven auxiliaries, is the general adoption of the multistage bleeding cycle for boiler feed water heating. Although complete motor drive for auxiliaries is not required where the stage bleeding cycle is used, electric drive for all auxiliaries in such stations will (1) decrease the B.t.u. per kw-hr. rate of the station approximately 2 per cent; (2) simplify operation by automatically varying with load changes the steam extracted for feed water heating, and (3) simplify the station heat balance system by obviating the transfer of auxiliary load with varying station load.

Another factor favoring the choice of electrically driven auxiliaries is the use of higher steam pressures and temperatures in modern stations. This is because (1) small high pressure auxiliary turbines cost much more than small low pressure turbines, and (2) higher pressure turbines are harder to maintain at their full efficiency and capacity. Operating experience with small turbines indicates that their efficiency falls off rapidly (sometimes as much as 50 per cent) unless they are carefully maintained. This diminishing of efficiency is due to an accumulation of scale in the steam passage; the effect obviously is more pronounced in high pressure turbines because of the smaller clearances.

The trend toward larger stations, which also involves of course larger boilers and turbines, is still another factor in favor of electric drive. These larger units permit the economical use of two or more similar auxiliaries per unit which allows for diversity in the auxiliary power supply and thus increases the reliability of electric drive. Furthermore, a more reliable unit system for auxiliary power supply is justified in these larger stations wherein all essential auxiliaries for a main generator are supplied directly or indirectly from the generator itself.

Cost Considerations

In addition to the many aspects of the choice of auxiliary drive already discussed, any comparison between the two drives introduces at least one other important factor subject to considerable debate—the cost of an electric auxiliary power supply that can be considered equally as reliable as steam. Naturally, the cost of any power supply system involves first of all the amount of power required to drive the auxiliaries.

Table I—Power Required for Electrically Driven Auxiliaries in a Modern Large Power Station

Subdivision	Per Cent of Total Auxiliary Power
Coal preparation	22.0
Boiler feed pumps	22.0
Turbine auxiliaries	22.0
Forced and induced draft fans	20.0
Heater drain pumps	3.8
Service pumps	2.6
Station lighting	2.4
Coal handling	1.6
Miscellaneous auxiliary power	1.5
Ash sluice pumps	1.0
Air compressor	0.7
Dust precipitators	0.4
Total (5.5 per cent of gross generated power)	100.0

For an electrically driven auxiliary system the amount of power required is relatively small and depends to a large extent upon the type of fuel-burning equipment used. For a plant burning pulverized coal, from 5.5 to 6.5 per cent of the total gross power generated is required for the auxiliaries; for one employing stokers, from 4.0 to 5.0 per cent; and for one burning gas or oil, from 3.5 to 4.0 per cent. The station load factor and nature of condensing water supply also affect the amount of auxiliary power, but to a lesser extent.

In Table I is given an approximate subdivision of auxiliary power for a typical modern 650-lb. steam-generating station of approximately 200,000-kw. capacity, entirely equipped with electrically driven auxiliaries and using the unit system of pulverized fuel equipment. A study of this tabulation indicates that at best the possibilities of further saving in the amount of auxiliary power appears to be limited to about 1 or 2 per cent of the gross generated power.

Table II—Investment Cost of Electric Equipment to Drive Auxiliaries of a Modern Large Station

Subdivision	Approximate Per Cent of Total Station Cost
Prorated share of cost for portion of turbo-generator units used for auxiliary power	0.8
Auxiliary power distribution system, including transformers	1.0
Motors	1.2
Control equipment for motors	2.0
Cable and conduit for motors and control equipment	2.0
Total	7.0

Investment in equipment is the next cost item considered. Accordingly, in Table II is given an approximate major subdivision of investment costs for the electrical parts of the auxiliaries for the same typical 200,000-kw. station. This station utilizes for auxiliary power two 4,000-kw. shaft generators, and two 9,000-kva. transformer banks connected to the main bus. The main switching equipment and the 2.3-kv. auxiliary switching equipment are of the vertical-lift metal-clad type; for the 440-volt motors air circuit breakers and magnetic switches are used. The boilers are supplied with full automatic control.

In Table II only the prorated share of the cost of turbo-generator units used for auxiliary power is included, because the boilers and the balance of the station equipment are common to both steam and electrically driven auxiliary systems. No allowance has been made for space occupied by electrical auxiliary equipment because it would be approximately the same for either type of drive; however, the flexibility of electric control equipment enables it to use space that otherwise might be wasted. In this particular case, the main auxiliary transformers and high voltage switching apparatus are installed out of doors.

Items in Table II exhibiting the greatest possibilities for saving are the control equipment and cables for motors. It seems apparent, however, that a radical reduction in the investment cost of the complete station will not result even from major modifications to the electrical part of an auxiliary system, but rather will have to come from a series of small savings. Some of the possibilities of making these small changes are brought out in the discussions which follow.

Electric Auxiliary Power Supply

A review of station designs with respect to the source of electric power for auxiliaries shows quite a variety of arrangements, all of which are modifications of two fundamental systems; (1) power from main bus, or (2) power from a separate generator. The advantages and disadvantages of the principal modifications of these two fundamental systems are covered completely in the National Electric Light Association *Publication 088*, April 1930, and will not be repeated here.

It is interesting to note a considerable trend back to the original system of supplying auxiliary power from the main bus after passing through a cycle of house turbines and shaft generators. The system of taking auxiliary power from the generator leads ahead of the oil circuit breaker is virtually the same as taking the auxiliary power direct from the main bus, and both are subject to the same criticism of being affected by bus voltage fluctuations unless the station has been designed to minimize them. In many instances, however, operating experiences appear to justify the use of these simpler and more efficient systems in large stations which form part of extensive interconnected networks.

Of the two methods mentioned, that of taking power from transformers connected to the generator leads is the least expensive because it eliminates the need for auxiliary high voltage transformer oil circuit breakers. The disadvantages of this scheme are substantially the same as for an auxiliary shaft generator except that the shaft generator of course is free from main bus voltage disturbances. Both are affected if the turbine overspeeds, but improvements in governors and the increasing use of generator voltage regulators for system stability purposes tend to minimize troubles of this sort.

If an electric auxiliary system is to be used in an isolated generating station, a more elaborate power supply obviously will be required. This type of station also will necessitate more steam driven reserve auxiliaries for starting-up purposes than now are considered necessary for a station forming part of a large interconnected group.

Although in some stations house turbine-generators have been employed, their economical use appears to be confined to stations using d-c. adjustable-speed motors or where exhaust steam is used for purposes other than for feed water heating. Many engineers feel that a house turbine is justified as a reserve to the other power sources and for starting-up purposes. The type of turbine-generator that can be started up almost instantly from a remote point appears well adapted for this purpose when local conditions justify its use. For all large stations, however, the unit system of supply appears justified, whether it be from house turbines, shaft generators, bus transformers, or transformers on generator leads. As already mentioned, the chief advantages of the unit system are greater reliability and lower interrupting duty on the auxiliary power control equipment.

Electric Auxiliary Power Distribution

Selection of the voltage for an electric auxiliary power distribution system usually is determined by the standard motor voltages available, together with a study of the over-all cost of motors, cable and control equipment. In many of the earlier stations, cable runs were relatively long and the interrupting duty on the control apparatus relatively light, with the result that motors of 50 hp. and more, usually were operated at 2,200 volts. However, with the present trend toward larger stations and consequent greater concentration of auxiliary power, the cost of control equipment has become a large item of the total auxiliary system cost. The 1926 report of the A.I.E.E. power generation committee pointed out this condition and suggested that a study be made of the possibilities of using a 440-volt auxiliary system with carbon air circuit breakers for control. It is interesting to note that a 460-volt system of this type was adopted for the Gould Street station at Baltimore as a result of a thorough study of investment costs and performance of motors and control. This station is designed for four 36,000-kw. units.

In larger stations with units of 50,000 kw. and upwards, two or more auxiliary distribution voltages usually are required; those commonly used are 2,300 and 460 volts, respectively, although in some stations 550 volts is being used in preference to 460 volts. In many instances an appreciable saving can be made in the over-all cost of motors, control equipment, and cable, by extending the size range of the low voltage motors up to 100 hp. or more, and establishing low voltage power distribution groups central to the group of motors fed by the distribution point.

Sometimes a further saving can be made in the auxiliary power switching and control equipment by diversified grouping of duplicate unit auxiliaries. For instance, half of the auxiliaries required for one boiler may be supplied from one bus section, and the other half from another bus section. This not only provides a more reliable power supply, but eliminates the need for double buses, since it is possible usually for maintenance purposes to isolate at least one-half of boiler auxiliaries during off-peak conditions.

Auxiliary Motors and Control

If the present high investment cost of auxiliary motors and control apparatus is to be reduced, every auxiliary drive application calling for variable or adjustable speed motors must be investigated and justified by an appreciable saving in over-all costs. In addition to the high investment cost, the use of variable or adjustable speed motors increases maintenance costs and space requirements and to some extent reduces the reliability of the drive.

A review of motor applications for recent large stations indicates a decided trend toward the use of more squirrel-cage and less slip-ring motors. Machinery designers are being attracted by the simplicity of the full voltage starting possibilities of squirrel-cage motors, and in many cases have withdrawn entirely their demands for slip-ring motors merely for smooth starting. Also some of the equipment which formerly required variable speed drive now is being made for constant speed operation with the exception of boiler feed pumps for high pressure boilers. Station designers too apparently are becoming more willing to give up in favor of the reduced investment and maintenance costs made possible through the use of the squirrel-cage motor, any small gains in plant efficiency obtained by variable speed drives.

In regard to motor control apparatus, considerable progress has been made by manufacturers in supplying self-contained motor control groups completely fabricated at the factory. In many cases where the field labor costs are high, a substantial saving can be made by using these factory fabricated groups. An appreciable saving also often can be made in conduit work by using armored cable installed in metal troughs or large pipes indoors, and by using "parkway" cable for outdoor installations. In the middle west during the past few years this method of handling cables has given satisfactory results.

Summary

The chief advantages of electric drive over steam drive for station auxiliaries are briefly:

1. It facilitates more efficient station design by permitting all of the steam required for feed water heating to be taken from the main turbine by stage bleeding.
2. It may be approximately twice as efficient in terms of B.t.u. per kw-hr. as steam drive depending upon the amount of maintenance received by the auxiliary turbines.
3. It is uniformly efficient, since lack of maintenance does not affect materially the efficiency of electrical equipment, although it may reduce the reliability of the equipment somewhat.
4. It requires less maintenance.
5. It is simpler to operate.
6. It improves the physical design and operation of a station by reducing the amount of auxiliary piping required, particularly in the basement.

Some of the possible methods introduced for reducing the cost of an electrical auxiliary system are:

1. Obtain auxiliary power supply from transformers connected to the main generator leads ahead of the generator oil circuit breakers, and reserve supply from main bus if reliable interconnections are provided with other stations and station bus is protected by reactors or their equivalent.
2. Establish both high and low voltage auxiliary power distribution groups central to location of auxiliaries instead of in electrical bay, to reduce length of cable and conduit runs.
3. Increase the horsepower range of low voltage motors in view of relatively high cost of high voltage control equipment.
4. Diversify feeds to all duplicate auxiliaries where possible, thereby permitting simpler switching layout for adequate maintenance.
5. Use squirrel cage motors and full voltage starting equipment wherever possible even if at the sacrifice of a small percentage in station efficiency.
6. Use factory fabricated control equipment wherever possible.
7. Use armored cables grouped in metal troughs or large pipes for indoor and "parkway" cable for outdoor installations.

How About the Human Side of It?

With sympathetic attention and the direction of modern scientific methods toward achieving a solution of existing problems in human relationships, an ideal civilization is foreseen. This is the sixth article in The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
ROBERT D. KOHN President, The American Institute of Architects

THE MATERIAL achievements of engineering and science during the past half-century indeed are an indication of the wonderful possibilities of the trained mind. But that same mind has not distinguished itself by meeting other problems that have grown even more complex in this same period. The benefits that men have received from science are fairly well known. Why try to make a list of them? Such a process appears academic. Is it not likely to lull us into a sleepy sense of repletion, as if the job were well done and, having dined on succulent self-praise, rest were now due? Or worse still, the pride of achievement actually may blind us to the important problem which science has not tackled at all. The present only-too-evident maladjustment (and indeed the misery from which some part of the world always suffers) is in no small measure an indication of a whole series of such vital problems.

It seems that the very real achievements of science and engineering fail of their effect because the human side of the world's problems has been neglected. We have been absorbed in *things*. We have neglected to notice the effect which men absorbed in things have upon other men absorbed in things. We have been proud, for instance, of what engineering has done to annihilate space. Transportation, telegraph, telephone, and the press bring men from the ends of the earth into a new and closer relationship with each other. But we have done practically nothing to develop a technique of human relations to meet the new problems brought about by those closer relationships.

The wonderful qualities of insight and patience, and indeed the genius that has been applied to the material accomplishments of modern times, now must be turned to a much more difficult job. The results of these discoveries must be turned to a more worth-while, a more comprehensive use. Scientists and engineers (and all of the rest of us for that matter) must now concentrate on the study of the relations of man to man, of group to group, and of nation to nation. We must find a way to understand the interrelation and the interdependence upon each other of men within each function of modern life, and the interdependence of function upon function. When these relationships are better understood they will become clarified, and then be more just. And the distribution of the products of modern methods and the benefits thereof (material as well as spiritual) then will be better adjusted, because of necessity that distribution will be based upon a recognition of the essential nature of the contribution that each group makes to the needs of the whole. And a whole world of latent talents will be evoked during this process.

By far the greatest benefits are still to be conferred on the world by the scientific mind and by engineering skill. They will produce in the future still greater inventions. The physical sufferings of mankind will be relieved by further beneficent discoveries of medicine and advances in surgery. But my hope for the future lies in the belief that we are about to shift the direction of our efforts because we have realized that progress lies in another direction. Doubtless the work in study and laboratory should go on, but the leaders of research and the forward-looking men in all the skilled vocations now must turn to a new leadership. It is their duty and their privilege to direct a study of the much more difficult problems in the neglected field of human relations, and these are not problems that can be solved by the few working alone in laboratories. It is a job for the many, out in the open with the whole world as a field of action. There is a new art to be created, superimposed upon material science, and next to which in complexity modern science is simple. An art it will be because it must develop a sensitiveness to the infinite variations, to the differences in values of personalities, and each such perception will have to be interpreted by other personalities.

The painful inefficiency and injustice of our present civilization shows us that this is the great task. Some say that the essence of this task is the basis of all of religion. Others believe that it is the spiritual background on which a new democracy is to be built. Whatever its name, it is a job that we must tackle, for we live in an age of idiotic contrasts. Part of the world is starving with the food bins elsewhere bursting with a surplus of food. The rest of the world is spiritually starving because of a plethora of the thousand-and-one material blessings. I am not interested now in a review of the scientific skill that has produced these things. I want to see it apply itself to working out a new vision of human relations.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles in this series.

A Brief Review of Contemporary Dielectric Research

SUPPLEMENTING the annual report of the chairman of the committee on electrical insulation, division of engineering and industrial research, National Research Council, which appeared under the title "The Trend in Dielectric Research" on p. 967-70 of the December 1931 issue of ELECTRICAL ENGINEERING, a résumé of technical and scientific papers presented at that committee's fourth annual meeting and conference held recently at Harvard University is presented in the four articles which follow. Each article is based upon the papers presented at one of the four technical sessions of the conference, each session dealing with one particular phase of insulation research.

In the first article F. M. Clark has digested and interpreted the contents of the papers presented at the session sponsored by the subcommittee on chemistry, of which he is chairman. The other three articles contain brief abstracts of papers presented at the remaining three sessions for the preparation of which the cooperation of J. B. Whitehead, chairman of the committee, and R. W. Atkinson of the General Cable Corporation, Perth Amboy, N. J. is acknowledged.

I—Chemical Research in Insulating Materials

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INSULATING MATERIALS of the type at present being used in electrical design are difficult to interpret from the standpoint of fundamental characteristics and behavior, not only because of their underlying complexities, but also to a large degree because of their lack of purity. As yet satisfactory methods for gaging the chemical purity of such materials have not been developed despite the fact that their electrical properties depend principally upon the presence or absence of electrolytic impurities. Insulation tests in use generally are electrical in nature nevertheless their exact relationship to the impuritie and chemical behavior of the insulation under test i largely a matter of speculation, and based but littl upon experimentally determined facts.

A striking example of the effect of impurities o dielectric strength is the fact that reducing the inorgani ash content of insulation by washing results in a marke improvement in its insulation resistance. About 7 per cent of the ash content of cotton consists of water soluble sodium and potassium salts; by removing thes a 50- to 100-fold increase in the insulation resistance i obtained. Of commercial importance is the fact tha washings with distilled water give lower insulatio resistance than similar washings with ordinary ta water which usually contains salts of calcium an magnesium. Apparently an ionic interchange i brought about between the alkaline earth salts of th wash water and the inorganic materials of the cotton In calcium sulphate washings, that portion of the sul phate content of the cotton not associated with alkalin salts remains remarkably constant regardless of change in the calcium content. With magnesium sulphat washings, the sulphate content decreases due to th greater solubility of the magnesium sulphate formed b the ionic interchange.

MOLECULAR STRUCTURE OF DIELECTRICS

From such data it may be assumed that the electrica properties of commercial dielectrics depend to a larg extent upon their physical structure. Conduction i not due to as great an extent to moisture condensed o the outer surface as to the presence of ionizable salt and moisture within the material itself. Studies o rubber and its purification have served to support thi view. Of considerable importance therefore is tha proper attention be given to the structural arrangement

[1]Based upon the following papers presented under the direction of the sub committee on chemistry of the committee on electrical insulation, divisio of industrial research, National Research Council, during the committee' fourth annual meeting at Harvard University, Cambridge, Mass., Nov 13-14, 1931:

1. Dielectric Constant and Molecular Interaction, by F. G. Keyes Massachusetts Institute of Technology.

2. The Structure and Electrical Behavior of Insulating Materials, b J. W. Williams, University of Wisconsin.

3. Molecular Structure and Valence, by J. C. Slater, Massachusetts Insti tute of Technology.

4. The Influence of the Ash Constituents of Cotton on Its Electrica Properties, by A. C. Walker, Bell Telephone Laboratories.

of the dielectric before attempting to build a superstructure of dielectric theory.

If atoms and molecules are conceived as being made up of positively and negatively charged particles, some structures evidently will be in good electrical balance, in the sense that the center of the electrical effect of the positive and negative charges will coincide perfectly. When placed in an electric field, such complex structures will polarize because the electrical center of the positive and the negative charges will be pulled out of coincidence. This change produces an induced polarity which, if independent of the manner in which the molecule is oriented, would be representative of the simplest dielectric behavior of gases. Peculiarities in the chemical constitution of the molecule, however, may bring about a disposition of atoms such as to give the molecule a permanent electrical moment in addition to an induced moment; in this case the dielectric constant would be expected to be greater. The orientation of fixed dipoles tending toward alinement parallel to the direction of the field would be expected to be interfered with by molecular collision; since such collisions are a function of the temperature, the result at infinite temperature would eliminate the contribution to polarization through the permanent moment. This theory has been remarkably successful and has stimulated an enormous amount of interest in dielectric behavior. Its extension by Debye and others has been made to account for anomalous dispersion at radio frequency and the absorption of energy in solids.

The extension of the molecular dielectric constant theory to highly compressed gases and liquids offers serious difficulties. To date measurements have been obtained at the Massachusetts Institute of Technology for carbon dioxide, ammonia, methane, and hydrogen. The results for carbon dioxide are typical of what may be expected of the dielectric behavior of a non-polar molecule or one having a non-permanent moment. A non-polar gas should possess a polarization independent of temperature; this is true of both carbon dioxide and methane. With carbon dioxide, the polarizability when extended to the region of liquidity under pressure increases only slightly with increased density. With ammonia, however, the increase in polarizability with density is more marked.

Molecular formation is based upon the attraction of constituent atomic electrons, and the valence bond giving atomic union is a resultant of electronic motion. As suggested by Lewis and confirmed by wave mechanics, homopolar bonds result from shared electrons. Electrons are considered to possess a spinning motion, and a chemical bond results from the mutual attraction of oppositely spinning electrons. Most of the electrons in an atom, however, are bound into closed shells with their spins neutralized. Thus only those electrons with unpaired spins can participate in the valence bond. The chemically inert properties of the helium family of elements is so explained. By the same reasoning, oxygen with its two parallel spinning electrons, a condition preventing mutual neutralization or bonding, offers an opportunity for multiple combination or double valence manifestation. The electrons, however, have a definite spatial arrangement and form bonds at particular angular relations to each other. In carbon, this characteristic results in chemical bond along the axes of a regular tetrahedron; in oxygen and in nitrogen, the bonds are respectively at right angles.

Behavior of Molecular Groups Must Be Considered

In commercial dielectrics, however, attention cannot be confined solely to the structure of individual molecules. To explain electrical conduction and other physical properties, consideration must be given to the behavior of the molecular *groups* which are influenced not only by simple molecular forces but, in addition, by those forces resulting in molecular *aggregation* and the formation of the massive material. Physical studies on cellulose, rubber, and other commonly occurring insulations indicate the presence of primary valence chains rather than aggregate formation by association through secondary valence forces. Primary valence chains are formed by polymerization or condensation reactions; their regular or random arrangement depends upon the number and spatial arrangement of the reacting group present in the elementary molecules. Substances possessing regular arrangements are known to be anisotropic while those having a random arrangement show the same physical characteristics in all directions. In the complicated system of wood, different conductivities are observed in different directions, but probably for a different reason. A number of regularly arranged cellulose macro-molecules are bound together to mi-cells which in turn probably are held together by amorphous cementing materials. The conducting paths in wood are between the mi-cells rather than between the macro-molecules. X-ray diffraction studies have contributed largely to the present study of these substances of high molecular weight.

To account for absorption and energy loss in dielectrics, the presence of free electrons, free and adsorbed ions, and dipoles has been speculated. The ability of dipole molecules to absorb enough energy to attempt to follow the alternation of the applied electrical field has been the subject of considerable discussion. It may well be doubted, however, that the orientation of dipole molecules can explain the energy loss in the molecular aggregates constituting the usual commercial insulation. The macro-molecules may be compared to long fibers, fixed in position and with but little tendency to follow the applied electrical field, even though they contain many polar linkings and groups. It is possible to conceive, however, that polar atoms or groups of atoms in such molecular aggregates may be displaced from their position of equilibrium by an electric field, thus giving rise to an absorption of energy. Because of the nature of the medium, characterized as it is by high

inner friction, the motion of these oscillations will be damped strongly. Therefore, a displacement of the group lagging behind the applied electric field will result provided its period is such that the moments of the groups may revert to practically their normal positions between alternations; an absorption of energy then will result. This behavior may constitute a factor which cannot be neglected.

II—Properties of Materials Probed in Dielectric Research

PROCEEDINGS of the second session of the insulation conference held recently at Harvard University (see footnote) are reviewed here. Like the preceding session under the guidance of the subcommittee on chemistry, this general session was featured by a distinct scientific atmosphere. Several papers were presented dealing with the electrical properties of important types of simple and complex dielectric materials as related to their availability as insulators.

Results of dielectric studies on vulcanized rubber, containing from 2 to 28 per cent sulphur within the temperature range of from 30 to 100 deg. cent. and within the frequency range of 60 to 2,000,000 cycles, were presented by D. W. Kitchin (A'29). More extended data on the well known anomalous dispersion and absorption of rubber sulphur compounds indicated that the theory of dipole orientation frequently evoked in this connection requires some modification. For example, the 600-cycle curve of dielectric constant *versus* percentage of combined sulphur shows no maximum, but rises steadily. Apparently the agents responsible for the anomalous electrical properties are present at any temperature, but their response to the field depends upon the physical state of the material. In tests on samples of high sulphur content, an increase in dielectric constant with temperature was observed. This is attributed to a polarization due to dielectric absorption, caused by particles having a wide range of relaxation times.

A series of studies on the dielectric behavior of solutions of cellulose derivatives in butyl acetate for the frequency range from 1×10^5 to 25×10^5 cycles was reported by J. B. Miles, Jr. For low cellulose concentration, the power factor and loss were shown to be accounted for completely by conductivity. This did not hold true for the higher concentrations, however, and it is suggested that the additional loss under those conditions is due to dipole orientation. Agreement with Debye's theory is lacking, though, and internal or molecular viscosity is suggested as a possible cause.

In an interesting speculative paper E. J. Murphy extended his proposal of last year, that dielectric absorption, or as he calls it "residual polarization" in certain dielectrics, is due to the presence of internal surfaces upon which ions may be adsorbed. The residual polarization is formed by the redistribution of the ions in an electric field; with increasing field; some of the ions may be separated from the surfaces. This would result in a decreasing dielectric constant and an increasing conductivity with increasing field intensity, the latter effect having been observed frequently. The author supported his theory by the results of some experiments with fine powders; in these tests both types of variation were in evidence.

Further data on the behavior of highly pure hydrocarbon liquids were presented in a paper by L. A. Welo who reported studies on normal decane, dimethyl octane, and on transformer oil. The liquids were studied through a series of successive distillations and cycles especially designed to remove moisture, air, and suspended matter not only from the liquids, but from the measuring system as well. In all cases, low conductivities (of the order of 10^{-18} mhos) were reached; the suggestion was made that the conductivities of all hydrocarbons including oils may be reduced to about this value, and that little if any variation of conductivity with structure is to be expected. When the 60-cycle power factors of these purified liquids were measured, losses about 10^6 times those computed from the conductivity were observed, indicating a large initial absorption or conductivity even in these purified liquids. The obvious explanation for this is that the application of continuous potential difference sweeps out a large number of ions which are active in causing dielectric loss in an alternating field, a picture which is supported by the saturation current-voltage characteristic of the conductivity measurements.

Measurements of irregularities in the conduction current of insulators subjected to constant voltage were reported by F. E. Haworth and R. M. Bozorth. These fluctuations or "noise" were observed by amplification as in the Schrott effect. It is indicated that ions or electrons impinge upon the electrodes in groups of increasing amount depending upon the field strength. The results support the idea that small conducting canals are created in the dielectric at field values considerably below that of breakdown and in increasing number as the breakdown value is approached; sudden discharges traverse the canals, thereby causing the current irregularities. However, the proportion of total current represented by these canal discharges is relatively small.

A paper presented by J. C. Balsbaugh (A'23) and P. H. Moon (M'29) described (1) a precision bridge for measuring the power factor of small oil samples, (2) ac-

Abstracted from papers presented at the second session of the fourth annual conference of the committee on electrical insulation, division of engineering and industrial research, National Research Council, held at Harvard University, Cambridge, Mass., Nov. 13-14, 1931.

curate adjustable air capacitors, and (3) oil cells to be used therewith. Further refinements were reported in electrostatic screening and in the electrical balance between guard ring and measuring electrode, points emphasized in the development of the Johns Hopkins bridges, with the result of a still further increase in the sensitivity available in bridges of the Schering type. Although no tests on the oils were reported, it is indicated that a sensitivity of better than + or − 10^{-6} in the value of loss-angle will be available; on account of the better control possible in the use of small samples, this should permit further refinements in such measurements.

III—Physical Theories of Dielectric Behavior

IN THE session of the Harvard University insulation conference (see footnote) held under the auspices of the subcommittee on physics, a series of five papers bearing on present physical theories of dielectric behavior was presented. In the first of these, W. F. G. Swann drew a series of analogies amongst the accepted mathematical developments of the theories of steady currents in conducting media, electric induction in non-conducting media, and magnetic conduction in magnetic media. Formal expressions for the fundamental phenomena in these three fields are known to be quite similar. It was shown, however, that there are certain aspects imposed by the restriction to constancy of specific resistance, constancy of permeability, and similar factors, and also by the nature of the mathematical solutions, which raise some question as to the complete accuracy of many accepted relationships. Notably, it is shown that in the general case of simultaneous electric and magnetic fields, it is possible to have at a surface of separation between two media, physical conditions which are not consistent with the usual assumptions made in this case.

As is well known, attempts frequently have been made to draw direct analogy between the properties of dielectrics and those of ferromagnetic materials. In discussing this question, H. Müller pointed out that the parallelism between Langevin's theory of paramagnetism and Debye's theory of polar molecules, suggests the possibility of finding insulators with dielectric properties analogous to the magnetic properties of a ferromagnetic substance. He concludes that such insulators may exist if (1) the substance contains a large number of polar molecules and the temperature is below the critical Curie value, and (2) the polar molecules are able to rotate without association. In support of these assumptions, measurements of the Kerr effect in Rochelle salts were reported.

A series of direct measurements of the relaxation time of abietic acid within the temperature range from 10 to 50 deg. cent. were reported by J. B. Whitehead (F'12) with corresponding measurements of dielectric loss. The method of analyzing dielectric losses which permits the separation of components (reported by A. Banos, Jr. later in the same session) was utilized for comparing the experimental behavior of abietic acid with the expressions proposed in the Debye theory of polar molecules, and with those of the Maxwell theory of dielectric absorption. It was shown that within the temperature range mentioned, the relaxation time is not continuous and that if polar molecules are involved, at least two types are present. The results in general, indicate a behavior in resin more in accord with the Maxwell theory of dielectric absorption, with progressive changes in conductivity and in viscosity accounting for the observed changes in dielectric loss. On the other hand, the experimentally observed change in dielectric constant apparently is not accounted for by either theory.

An interesting series of studies on the oxidation of insulating oil was presented by H. H. Race (A'24). A certain commercial oil was separated into nine samples; these were heated in contact with air at different temperatures for different lengths of time under which conditions studies were made of a number of properties such as conductivity, dielectric loss, spreadability on water, acid number, and viscosity. The results on oxidation were discussed from the standpoint of Debye's theory of polar particles, with conclusion that the number of the particles varies rather than their size. Other studies of the correlation of various properties also were given, with the conclusion that the spreadability test in conjunction with the variation with frequency of dielectric loss under oxidation are the most promising methods for studying progressive changes in insulating oils.

Detailed results of an analytical study of the method for utilizing continuous potential charge and discharge currents observed by the amplifier oscillograph for the prediction of dielectric behavior under alternating stress, were reported by A. Banos, Jr. It was shown that if the portions of these oscillograms for an initial time interval corresponding to the period of the alternating cycle be employed, the current variation may be expressed as the sum of three terms, each containing a negative exponential of the time. This expression, when substituted in von Schweidler's equations, permits the computation of dielectric losses which agree almost exactly with actual measurements. The analytical study with accompanying curves and measurements of loss, power factor, and capacitance, show the reliability and accuracy of the method.

Abstracted from papers presented at the third session of the fourth annual conference of the committee on electrical insulation, division of engineering and industrial research, National Research Council, held at Harvard University, Cambridge, Mass., Nov. 13-14, 1931. This session was sponsored by the subcommittee on physics.

IV—Dielectric Research Presages Cable Improvement

THE FINAL SESSION of the insulation conference held recently at Harvard University (see footnote) was devoted more to the practical engineering application of dielectric materials. Ten papers were presented, all of which are reviewed briefly.

In a paper entitled "The Electrical Properties of Impregnated Cable Paper and of Ionized Gas Films," C. L. Dawes (M'15) presented the results of an extended series of dielectric loss measurements in impregnated paper as related to voltage, frequency, and temperature variation. Both sections of cable and laboratory samples with air layers were studied. Several empirical laws were reported, notably for the change in the type of variation with temperature and for the nature of the loss caused by the presence of "ionization" films. Studies such as this involving as it does investigations into the effects of the characteristics of a dielectric's component parts upon its behavior as a whole, have come about from a recognition of the structural nonhomogeneity of dielectrics and have had an important bearing upon the recent great improvements in commercial products.

The apparent presence of an appreciable power factor (of the order of 10^{-5}) in the air capacitors such as those used in dielectric loss measurements, was brought out by J. C. Balsbaugh (A'23) and P. H. Moon (M'29); the importance of making allowance for this in a-c. bridge measurements using such capacitors was emphasized. This condition is attributed to gas, either adsorbed in the electrode surfaces or forming layers thereon, a belief supported by changes in power factor which took place when the air pressure within the capacitor was varied. Influence of variations in the electrode material, and of different types of surface layers of the same material also were studied. In the discussion, two speakers, one of whom was from the U.S. Bureau of Standards, reported experiments on this subject; in neither case was evidence of the presence of power factor in capacitors discovered.

Development of the sensitive measuring equipment used in this study of residual losses in air condensers came about as a direct consequence of the improvements in dielectrics which resulted in requests from utility engineers and manufacturers for equipment capable of making adequate measurement as improvements are continued further. The more obvious imperfections of air condensers that have caused some trouble to earlier investigators were fully eliminated; present investigations, requiring as they do the use of a condenser as a primary standard, not only involve precise electrical measurements, but also necessitate a fundamental study of both the condenser and its electric field.

In two papers, J. B. Whitehead (F'12) reported further experiments at Johns Hopkins University on the properties of impregnated paper used in high voltage cables. The first one described how, by measurements with the amplifier oscillograph of the short time d-c. conductivity and absorption of the oil and the paper separately and in combination, it is possible to follow the separate influences of each on the behavior of the final product very much more closely than heretofore. New evidence was presented as to the correlation between the physical characteristics of the oil and the separate components of the total loss in impregnated paper. The method used was an accelerated life study, samples being tested by the application of successively increasing voltages, starting with 400 volts per mil. A highly refined light oil showed a life greatly in excess of most of the other oils studied; second came an oil of naphthene base; thereafter, in a group in which the variations in life were not great, came a number of oils commonly used in cable manufacture. In the discussion of these results, it was indicated that while the electrical characteristics and the life of the light oil were of high order, oils of this type were not suitable for practical use because of their rapid deterioration, both in the process of manufacture and under those conditions pertaining to cable operation which are not present in laboratory studies. Another interesting result was that although the naphthene base oil had relatively long life, its power factor and loss were so high as to render its use in cables prohibitive. The results in general emphasize the fact that while oils of highly desirable characteristics and long life may be obtained, it may be impossible to use them practically, because of the limitations imposed by the handling and operation of cables in long lengths.

The second of these two papers is a part of a series involving a study of the electrical characteristics of condensers made with commercial or semi-commercial materials and prepared under accurate laboratory control of conditions varied according to a prearranged schedule. The resulting data are adding materially to existing comprehensions of dielectric characteristics.

Interesting results on the influence of high oil pressure upon the electrical endurance of cables were reported by J. A. Scott (A'25). Experiments were made both on cables and on sheet paper immersed in oil. By the application of a pressure of 80 lb. per sq. in. above atmosphere, the dielectric strength of the cable was found to be doubled, with a similar though lesser increase observed in the sheet paper experiments. The effect of pressure on the strength of cable insulation containing voids or bubbles has been recognized fully and studied extensively, but the meagerness of earlier data on the subject discussed by the author adds to the importance of his contributions. Full development of

Abstracted from papers presented at the fourth session of the fourth annual conference of the committee on electrical insulation, division of engineering and industrial research, National Research Council, held at Harvard University, Cambridge, Mass., Nov. 13-14, 1931.

the laws governing the effect of pressure on dielectric properties is important both from the standpoint of dielectric theory and from that of practical application.

A discussion of the voltage-time characteristics of saturated paper insulation next was presented by R. W. Atkinson (F'28) accompanied by new data based upon extensive experiments on the breakdown life of cable samples under impulse and accelerated voltage step experiments. The results show clearly the limitation of the commonly-used straight hyperbolic voltage-time relation, and the wide error which may result. The experiments reported indicate that within the range of from 5 min. to 500 hr., the voltage-time relation is more closely represented by a formula in which the breakdown gradient is made up of two terms: (1) a constant term representing the voltage which the insulation will stand for indefinite time, and (2) another term inversely proportional to a root of time varying from 1.5 to 4. Especially interesting were the studies of breakdown under impulse voltages, these indicating values very much less than those computed from the law just stated. Indications are clear therefore that formulas of this type are suitable only for studies on the same type of material and within a range of time in which they are known to be applicable. The obvious suggestion is that the impulse breakdowns are perhaps of straight electrical character, whereas the breakdowns under sustained voltage involve other factors such as perhaps local liberation of internal heat. Other data indicate that high-density papers have higher dielectric strength than lower-density papers within the time range mentioned. Another striking fact is that great variation in the shape and slope of the voltage-time curves are found with different types of impregnating material; thus the curves for different compounds may cross not only once but even twice. These data help to indicate the inaccuracy of comparing the qualities of dielectrics without taking into account these variations in the shape of the voltage-time curves.

An extensive series of studies of high voltage cables under operating conditions, involving daily measurements of power factor, loss, and ionization through temperature cycles and at excessive voltages, was reported by R. J. Wiseman (F'27). A feature of this paper was the description of the laboratory arrangement and testing equipment which provided for testing cables carrying heavy current while under voltage stress. The cable ends were sealed and internal oil pressures were measured as were the dielectric losses and the duration of cable life. Based upon an illuminating continuous record of the experiments, the author discussed various factors bearing on cable behavior and the importance of improvement in methods of studying and controlling these factors. Significant data also were given as to bursting stresses to which the lead sheath was subjected by the load cycles imposed.

The deterioration of oils under a-c. corona discharge next was discussed by K. S. Wyatt, in continuation of his work on the deterioration of and wax formation in oils such as used for the impregnation of paper. In the experiments the oil was subjected to corona discharge, the gases formed thereby forcing the oil into a power factor measuring chamber. From the latter, the oil due to its own weight flowed back into the original discharge chamber, thus permitting a circulating action and continuous observation. The results showed a marked increase in the dielectric loss with duration of corona exposure. In the case of a water-white paraffin-base oil, in thirteen hours the power factor increased from 0.4 to 4.1 per cent. The exact nature of the increased loss is under further investigation.

The occurrence of ultraviolet light and X-radiation from gaseous discharges within the body of insulation were topics discussed by E. B. Baker and R. F. James. These types of radiation are thought to be caused by electrons and ions falling through high local stresses before collision with the matter. Experiments were reported showing that the production of such radiation usually is associated with unequal potential distribution in the dielectric, a condition often noted. Importance of the question lies in the possible deterioration of the dielectric structure by the ultraviolet and X-radiation.

Further results of the continuous study of cable performance and quality were outlined by D. W. Roper (F'14) these being carried out on the cable systems and in the laboratories of the Commonwealth Edison Co. (Chicago) and correlated with factory tests. The records of nearly 300 miles of 66-kv. cable and a large amount of 33-kv. three-conductor cable over a number of years are reviewed and a number of important deductions made. Two accelerated life or aging tests are discussed. One of these, involving a test voltage of about twice operating voltage and with cycles of heating and cooling, is much more discriminating and valuable than a test at high voltage and without heating cycles. It gives results consistent with practical cable operation; this correlation with extensive operating experience is suggested as establishing the test as an adequate method of proving the satisfactoriness of any given type of cable to meet standard operating conditions. While the establishment of such a test and its relation to operating performance is an important adjunct to effective future developments, it emphasizes the necessity for the development of a laboratory test to predetermine the stability of an impregnating compound under service conditions, and for a factory test adequate to eliminate sections of cable having local imperfections.

Cables performing perfectly under normally heavy loads were shown to have been those saturated with a tacky impregnating compound which in two cases consisted of a mineral oil and in the other two, compounds containing rosin or rosin oil. Presence of rosin or rosin oil, however, does not necessarily mean that a compound will be satisfactory for fully loaded cables; but all cables having a perfect service record with normally heavy loading for long periods, had a low ionization factor. For lightly loaded cables these same qualities seem desirable, but apparently not as necessary.

Measuring Core Loss at High Densities

Modern electrical machines employ flux densities in excess of those previously measurable by routine methods. The refined method now available for densities up to 20,000 gausses therefore is recommended for adoption as standard.

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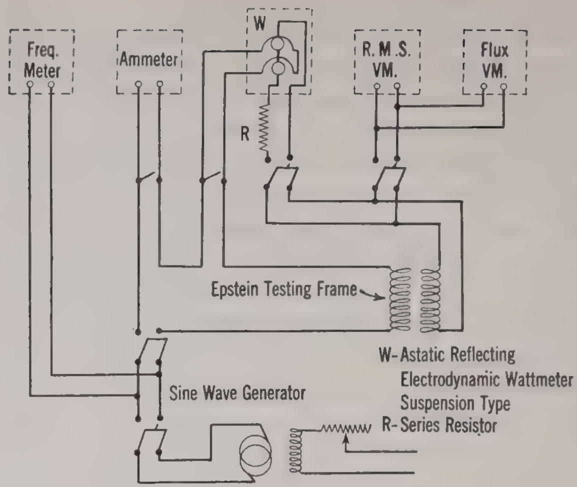


Fig. 1. Connection diagram of method for core loss testing at high flux densities

GREATER ECONOMY and efficiency of electrical apparatus require a better knowledge of the core loss values for magnetic sheet steels at high flux densities than heretofore has been available. The Epstein method adopted as standard by the American Society of Testing Materials is at present the routine method of making core loss measurements at normal densities. However, it is inadequate for measurements at densities above $B = 14{,}000$ gausses, and refinements have now been worked out in the new scheme which make it possible to extend the core loss measurements on sheet steel up to $B = 19{,}000$, and on some sheet steel up to $B = 20{,}000$. Although previously a sine wave of applied voltage has been necessary for accurate measurements, the new method does not require the maintenance of a sine wave of induction in order to obtain a true measure of the maximum flux density.

The over-all accuracy of the measurements obtained by this new method approaches the accuracy of 2 to 3 per cent specified for the standard Epstein apparatus and is well within the accuracy of sampling sheet steel. Because of its accuracy, simplicity, and convenience, this method is recommended for use as the standard method in core loss measurements, so that routine acceptance tests may be extended to the high flux densities met in actual practise.

The testing equipment used for obtaining core loss data at high flux densities consists of an alternator of sufficient capacity, an Epstein testing frame, an ammeter, a frequency meter, an r.m.s. voltmeter, a flux voltmeter, and an astatic reflecting electrodynamic wattmeter, connected as shown in Fig. 1. All of these instruments except the flux voltmeter and the wattmeter are included in the present routine test equipment as described in the A.S.T.M. specifications. The wattmeter, while not a portable instrument, is commonly used in laboratory testing. The flux voltmeter consists essentially of a rectifier and a d-c. voltmeter of the D'Arsonval type, so that the indications are directly proportional to the maximum flux density in the test specimen regardless of the wave shape of the induced voltage.

Based upon "Core Loss Measurements at High Flux Densities" (**No. 31-77**) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

The method previously in use requires that a harmonically varying induction be set up in the test sample by the application of a voltage of sine wave form across the magnetizing coil of the test frame. This method cannot be applied accurately to high density work. The chief difficulty is the large magnetizing force which causes (1) a distortion of the flux wave, (2) a large flux in the test coil and (3) a low power factor.

Distortion of the Flux Wave

The distortion of the flux wave operates as a source of error in two ways: First, if the maximum flux density B_m is determined by an r.m.s. voltmeter in the secondary circuit according to the well known formula, based on a sine wave voltage, the result will be erroneous. Secondly, it introduces additional losses in the specimen due to high frequency components of the eddy currents. The theory of the method of determining the maximum flux density regardless of its wave shape is based on the following:

1. The maximum alternating flux density is proportional to the arithmetic average value of the induced voltage regardless of the wave form of the voltage.
2. If an alternating voltage rectified without changing the wave shape is impressed on a d-c. voltmeter of the D'Arsonval type, the instrument indications are proportional to the arithmetic average value of the rectified wave which is the same as the arithmetic average of each half cycle of the unrectified a-c. wave.

Measuring the average voltage (*i. e.*, the arithmetic mean value of a half cycle of the voltage wave, corre-

sponding to the point of extreme variation of flux in the associated flux wave) instead of the r.m.s. voltage eliminates the previously mentioned error in the measurement of B_m and makes it possible to determine the true maximum value of the flux irrespective of the distortion.

It should be noted that when B_m is correctly determined, the hysteresis component of the core loss also is correct, the error in the measurement being entirely in the eddy current loss. Since the total eddy current loss is in general a much smaller quantity than the hysteresis loss, it is obvious that the correction to the eddy current loss is a correspondingly small percentage of the total loss. The error in the measured loss cannot be eliminated but can be corrected readily by any one of a number of methods. The simplest and most rapid of these is the per cent eddy method, as it requires fewer test data and calculations. The accuracy is well within the limit of measurements and the method therefore especially is recommended for routine testing. In this method, the percentage of eddy current loss for a sine wave of induction is assumed based on data obtained on similar material. The sine wave core loss is calculated by the relation

$$\text{Sine-wave } W/\text{lb.} = \frac{W/\text{lb} \times 100}{h + k\,e}$$

where

e = assumed per cent eddy current loss
h = 100 − e or per cent hysteresis
k = ratio $\left(\frac{E_{r.m.s.}}{E} \right)^2$
$E_{r.m.s.}$ = the r.m.s. value of the induced voltage
E = the average value of the induced voltage

The form factor k can be computed from simultaneous readings of the r.m.s. voltmeter and the flux voltmeter.

The area enclosed by the potential coil of the Epstein test frame necessarily is larger than the sample area. This necessitates a correction for voltage induced by the air flux. At low magnetization values this is negligible, but at high flux densities when the magnetizing force required is large, the correction is appreciable and must be applied as described below.

The total voltage induced in the potential coil is given by the formula

$$E = E_i + E_a$$

where

E = the r.m.s. value of voltage required
E_i = the voltage induced by the flux in the core
E_a = the voltage induced by the flux in the air space

E_a is called the space factor correction voltage. This often amounts to 4 per cent of total voltage at the highest H values, and if ignored would produce a corresponding percentage error in the flux density. Since the voltage E to be maintained always is computed on a sine-wave basis regardless of the form of the induced voltage wave, we have

$$E_i = 4.44\,B\,N\,A\,F\,10^{-8}$$
$$E_a = 4.44\,H\,N\,(a - A)\,F\,10^{-8}, \text{ whence}$$
$$E = 4.44\,N\,F\,10^{-8}\,(B\,A + H\,(a - A))$$

in which

B = maximum flux density in the iron
N = potential coil turns
A = area of test sample in sq. cm.
F = test frequency in cycles per sec.
a = area enclosed by potential coil in sq. cm.
H = air flux in gausses. This is equivalent to the magnetizing force in gilberts per cm. For the purpose of computation, the value of H is usually taken from a d-c. magnetization curve of representative material

The low power factor of the circuit emphasizes the small phase angle error inherent in every wattmeter and also requires that an instrument of large current capacity and high sensitivity be used. The desired characteristics are obtained by the use of a suspension type astatic reflecting electrodynamic wattmeter. This instrument by its high sensitivity permits the use of a current coil of few turns of heavy cross-section conductor. It also permits a potential coil of few turns; that is, a very small inductance and a comparatively large resistance.

At first it was expected that the non-uniformity of the flux distribution over the length of the sample might be a source of considerable difficulty. Tests, however, have shown that the non-uniformity at high flux densities is no greater than at the moderate densities for which the Epstein apparatus was designed; therefore it was assumed that for the present error from this source could be ignored.

The test procedure is essentially the same as that for testing at normal densities. A 10-kg. sample of 50 x 3 cm. strips is made into four bundles and inserted in the test solenoids with paper separators at the joints as described in the A.S.T.M. specifications. The steps are then carried out as previously described.

Some illustrative core loss curves obtained by the routine method are given in Fig. 2. The characteristics

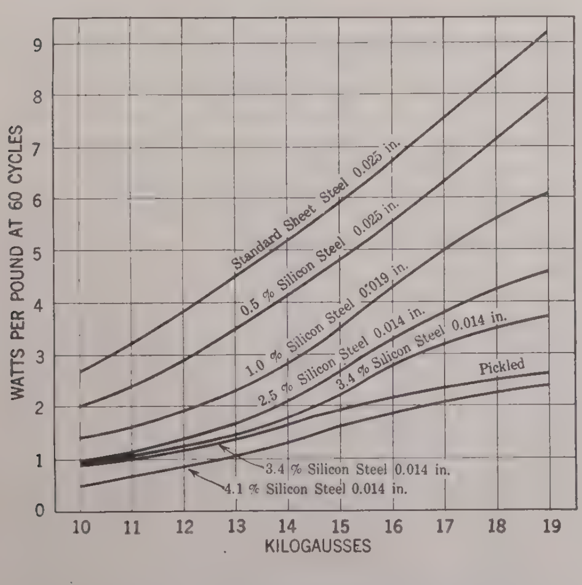
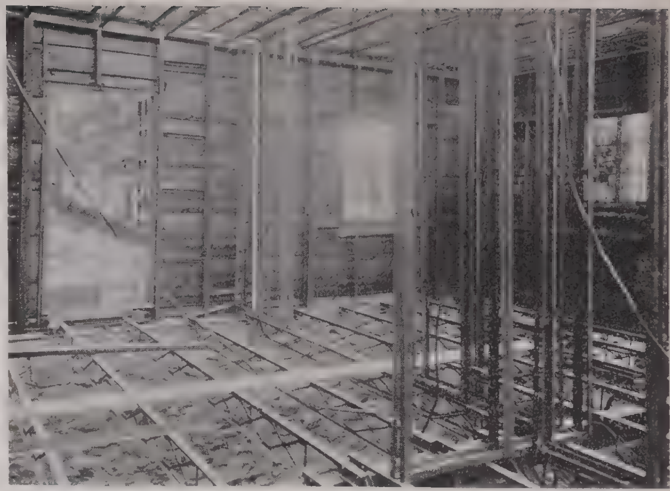


Fig. 2. Core losses of magnetic sheet steels

of these curves at high flux densities when compared to those at normal densities show the value of these measurements; the reversal of the silicon steel curves confirms what was theoretically expected but seldom shown. It is interesting also to note the effect of scale on the losses at high flux density as illustrated by the two curves of 3.4 per cent silicon steel; one represents the losses before pickling, and the other, the losses after removing the scale. The benefits of this treatment are shown by the measurements to be obtainable only at high flux densities.

The accuracy of these measurements approximates very closely the accuracy of the Epstein apparatus under the normal test conditions at $B = 10{,}000$. This was demonstrated by tests using both sine and distorted waves at this density. Excellent agreement was found between the sine wave core loss and the corrected losses obtained with distorted waves.

The method described is adaptable to the widely used Epstein equipment, combining all the advantages of simplicity, convenience, expeditiousness, and accuracy of that method. In addition, it may be extended into much higher densities. Therefore it is recommended for use as the standard method for core loss measurements in order that routine acceptance tests may be made at flux densities more nearly equaling the highest working densities of modern machines.



General Elec. Co. Photo.

Fig. 1. (Above) Interior view of panel type arc welded framing during course of construction

Lincoln Elec. Co. Photo.

Fig. 2. (Right) Arc welded house frame being fabricated on the job from standard structural shapes

Residences with Arc Welded Steel Frames

ARC WELDED steel framing for dwelling houses is representative of some of the recent experiments in modern building construction. Many advantages are claimed for the welded type of construction, among them being: rapidity and noiselessness of construction, flexibility of design, rigidity and solidity, low rate of depreciation, and a lower insurance rate resulting from the fireproof construction which this method makes possible. What is more important is the fact that all of these advantages may be realized without any appreciable increase in cost over older methods of construction.

Two methods of construction are indicated in the two illustrations. These do not represent any freak combination of new materials but embody only tried and proved engineering principles and construction methods already being applied to larger and taller buildings. Interior and exterior appearances of the finished houses are no different from those of similar houses built by older methods, but notwithstanding this the possibility for individuality in the design and layout of arc welded frame dwellings is thought to be greater than that allowed by present construction.

The entire framework including all interior partitions, of the house shown in Fig. 1, was made up of standard sized panel frames previously fabricated in the welding shop. As may be noted, duplicate frames were used throughout, these being tied together with spacers to provide standard wall thickness. Two sizes of panels were used: namely, 2 x 9 ft., in wall sections without windows or doors, and 6 x 9 ft. for sections including window or door openings. Gable sections were fabricated in the shop, then trucked to the building site and welded to the framework proper.

A somewhat different type of construction is illustrated in Fig. 2; in this case standard steel shapes delivered to the building site like lumber were used throughout without shop fabrication of any kind. Three workmen erected the 10 tons of steel required in this building with no other tools than squares and the usual arc welding equipment.

Abstracts

Of Papers to be Presented at the Winter Convention

INTERPRETIVE abstracts of the majority of papers to be presented at the A.I.E.E. winter convention (January 25-29, 1932) are presented herewith, excepting only those papers published in this issue of ELECTRICAL ENGINEERING and those not available for publication at the closing date of this issue. Abstracts of the remainder of winter convention papers are scheduled for publication in the February issue. Members vitally interested and wishing to obtain immediately pamphlet copies of any available papers are requested to use the order form appearing on p. 70 of this issue. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

New High Speed Distance Relay With Impedance-Reactance Characteristic

By
S. L. Goldsborough[1]
W. A. Lewis[2]

THE TWO general types of distance relays for isolation of faulty sections of transmission line are impedance relays, operating upon the impedance of the line between the relay and the fault, and reactance relays, operating upon reactance alone. Each of these types has certain advantages as well as certain disadvantages; it is the purpose of this new relay to combine the principal advantages of both types.

The impedance relay is fundamentally more simple, and can be made to operate at a considerably higher speed. However, the presence of accidental arc resistance at the point of short circuit increases the impedance as viewed from the relay, and makes the fault appear more distant than it really is. On the other hand the reactance relay is affected to a less extent by the presence of arc resistance, but in general requires a more complicated structure which does not lend itself readily to obtaining high speed. Furthermore, additional features are required to prevent the operation of this type of relay under normal load conditions. Difficulty is also experienced in making the auxiliary features operate properly in all cases.

Although a relay of this new design can be made to operate as a pure reactance device, it is believed that more satisfactory operation can be obtained by an intermediate characteristic. This modified characteristic permits a relay to be obtained which combines the mechanical simplicity and inherent possibilities of high speed of operation, so desirable where stability is a factor, and the greater independence of the reactance type relay from the effects of fault resistance on the shorter lines. (**A.I.E.E. Paper No. 32M1**)

1. Westinghouse Elec. & Mfg. Co., Newark, N. J.
2. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

The Theory of Oil Blast Circuit Breakers

By
D. C. Prince[3]

DIRECT experimental proof of the oil blast theory of arc interruption has been assembled. A circuit breaker has been constructed having oil driven between its electrodes at a measurable velocity, and tests show that a correlation exists between the rate of recovery voltage rise and oil velocity. This correlation corresponds to an oil dielectric strength of 55 kv. per 1/10 in. of oil. To determine whether or not this correlation is accidental, relations between voltage and oil velocity and between current and oil velocity have been studied, but correlation does not appear. Impulse tests also have been made on clean and carbonized oils.

Comparative data are available for various methods of forcing the oil blast between the electrodes. It has been found that at the current zero there is a correlation between voltage recovery rates and chamber pressure. This result is surprising since the relation between pressure and oil flow are complicated by the circuit, of passages, back pressure due to oil head and gases generated by the expelled arc.

The laws which govern all variables involved in the design of oil blast circuit breakers are known with the exception of the amount of energy developed by the arc, and even this factor has been observed empirically. Although considerable refinement of the oil blast theory remains to be done, as a whole it rests upon the secure foundation of comprehensive tests and calculations. (**A.I.E.E. Paper No. 32-8**)

The Practical Application of the Oil Blast Principle of Circuit Interruption

By
R. M. Spurck[3]

DEVELOPMENTS in theory, calculation, and test results of circuit interruption by means of the oil blast, have placed new tools in the hands of designers, enabling them to construct apparatus of greater efficiency and consistency of performance than heretofore possible. Various applications of these new methods have been made to circuit breakers of all classes and voltages. Circuit breakers equipped with the oil blast device show consistently short arc lengths and unusually short periods of arc duration, even at high rates of recovery voltage rise and over wide ranges of current. The result of this is that contact burning and oil deterioration are minimized and maintenance is greatly reduced. The rapid arc extinction characteristic of the oil blast design makes it admirably suited to breakers requiring high speed of operation.

In most types of circuit breakers, the method of securing the oil blast is by having an auxiliary gap which opens first and by means of the arc formed generates gas to create pressure within the chamber. As the main gap opens, the pressure generated by the auxiliary gap is forcing oil at high velocity through the main

3. General Electric Company, Philadelphia, Pa.

gap and down through the contact rod so that the arc products in the main gap are replaced with solid oil of high insulation value which resists puncture by the recovery voltage and at an early current zero prevents further current flow. In a new circuit breaker of very high operating speed the oil blast is obtained, not by the generation of gas in an auxiliary blast but by a piston acting in a cylinder containing oil. (**A.I.E.E. Paper No. 32-9**)

3. The recovery of dielectric strength following a current zero by an a-c. arc subjected to turbulence takes place in two consecutive phases; the first consisting of a very rapid recovery to a substantial value in a few microseconds, and the second of a very much slower further recovery for a much longer period.

4. At least one practical gas blast circuit interrupter, the expulsion fuse, exhibits a volt-time interruption characteristic which clearly indicates the role of gas turbulence in its operation. (**A.I.E.E. Paper No. 32-11**)

Recent Developments in Arc Rupturing Devices

By
R. C. Van Sickle[2]
W. M. Leeds[2]

THE EXTINCTION of an a-c. arc by the deion grid method has been very successfully applied during the past two years to the design of an extensive line of arc rupturing devices for oil circuit breakers of all voltage classes. Refinements have been made in the theory of operation of deion grids and in the construction of several types. Field operation and special tests have given much information regarding these devices.

With the deion grid circuit breakers the arc in oil is drawn through a narrow insulated slot open at one end, and magnetically forced into a series of oil pockets. The gas generated can escape only by passing through the arc stream so that the arc is subjected to a continuous turbulent blast of fresh un-ionized gas. A dielectric strength of perhaps twenty times the arc voltage is established within a very few microseconds, and is further increased as deionization continues with the aid of the gas blast.

Laboratory tests have shown that the replacing of plain or quick-break contacts by deion grids reduces the duration of arcing on a 66-kv. circuit to only from 1/4 to 1/7 of the former arcing time, while the arc energy was only from 5 to 10 per cent of the values associated with the old style of contact. Similar results have been observed with circuit breakers for all other classes of service. These results mean great improvement in system stability, reduction in contact depreciation and oil deterioration, and make possible long periods of service without maintenance to the circuit breakers. (**A.I.E.E. Paper No. 32-10**)

High Voltage Bridge for Measurements of Cables with Grounded Sheaths

By
C. L. Dawes[4]
A. F. Daniel[4]

PRECISION bridge measurements are now in use for measuring the dielectric properties of cables when the current through the dielectric can be conducted directly from the sheath to the measuring apparatus. As a rule, however, these methods cannot be applied to cable with sheaths in electrical contact with ground. There is one method in which bridge measurements are made of all system losses, with and without the test cable connected in the circuit; the difference gives presumably the power loss in the cable dielectric. This method does not give the cable electrical properties (power, power factor, and capacitance) directly, and special precaution must be taken in connecting the cable.

There has been developed a bridge method which does measure directly, and with a high degree of precision, the values of the electrical properties of the test cable even though the sheath of the latter may be grounded. In this method, a four-arm bridge consisting of a standard air condenser and some condenser or cable other than the test cable is first balanced, with the terminal of the galvanometer at the condenser or cable grounded. This balances all system losses to ground. Then the bridge is rebalanced with the test cable connected in circuit. After this last balance, none of the current through the test cable can flow to ground, but must flow through its appropriate bridge arm. The dielectric measurements and also the cable properties thus are read directly from the bridge balance and do not involve correction for system losses. (**A.I.E.E. Paper No. 32-12**)

Extinction of A-C. Arcs in Turbulent Gases

By
T. E. Browne, Jr.[2]

IN CIRCUIT breakers employing arcs submerged in liquids such as oil, carbon tetrachloride, or water, the surrounding liquid surface serves both to restrict the arc space and to furnish a gas blast by rapid decomposition under the influence of the high temperature arc. The fiber tube of the common expulsion fuse acts in a similar manner. In the liquid circuit breakers, various devices are available to increase the interaction between arc and liquid, thus aiding in arc extinction.

The results of recent experiments to obtain conclusive evidence of the actual mechanism of such action reveal the following facts:

1. In general, the interrupting ability of an a-c. arc is greatly improved by turbulent motion of the arc gases, in a fast circuit this improvement increasing almost in direct proportion to the gas velocity from which the turbulence results.

2. The interrupting ability of a turbulent a-c. arc depends very largely upon the composition of the arc gases, most gases being decidedly superior to air in this respect.

A High Sensitivity Power Factor Bridge

By
W. B. Kouwenhoven[5]
A. Banos, Jr.[5]

AN A-C. BRIDGE of high precision has been developed for power factor measurements in an investigation of the properties of cable compounds and papers and of the characteristics of cables that occur after impregnation. The bridge, a modified form of the Schering bridge, possesses several novel features and advantages. The detecting instrument is a moving coil a-c. galvanometer with field excitation supplied from a phase shifting transformer permitting independent ratio and phase-angle balances. A shielded transformer electrostatically isolates the galvanometer from the bridge circuits. This bridge is completely shielded and guarded.

The analytical theory of the resulting mesh connection has been developed in a general manner so that this mathematical treatment may be applied to any similar network. Complete study has been made of the effects upon the balance relation of various sources of error, such as for example, failure to balance

4. Harvard University, Cambridge, Mass.
5. Johns Hopkins University, Baltimore, Md.

guard circuits properly and the presence of leakage resistance between measuring and guard circuits. Experimental verification of the equations has been produced. Power factors of specimens of cable material have been measured ranging from 0.00007 to 0.16 with a maximum variation of ± 0.000005. **(A.I.E.E. Paper No. 32-13)**

Power Factor Measurement by the Capacitance Bridge

By R. P. Siskind[4]

SEVERAL types of capacitance bridge for the measurement of both capacitance and power factor of dielectric specimens are in use at the present time. Some of these make a direct comparison between the capacitance under test and a standard capacitance. For accurate power factor measurements upon dielectric specimens at low voltages and audio frequencies, however, a substitution method is generally preferred. Two substitution methods which may be referred to as the "direct" and the "parallel" are commonly employed. With each method, a small change in the phase angle of the arm of the bridge circuit in which the substitution is made occurs. The compensation for this change enters directly into the measurements, and the essential differences between bridges in common use is in the manner of making this adjustment.

A recommended type of capacitance bridge has been developed having the following advantages:

1. All operating controls are at ground potential reducing the effects of hand capacitance to a minimum.
2. The bridge is entirely self-contained except for oscillator, amplifier, and telephone receivers.
3. All parts except the high-potential terminal for the lead to the test specimen are shielded totally.
4. All controls are variable continuously.
5. The bridge may be constructed entirely of standard parts, the shielding excepted. **(A.I.E.E. Paper No. 32-14)**

The Photoelectric Recorder

By C. W. LaPierre[6]

THE MOVING parts of electric indicating instruments may be light in construction and of low torque, thus requiring small energy input from the circuit being measured. When it is desired to record these measurements, however, the moving parts are usually heavier in weight and require higher torque than the corresponding parts of indicating instruments.

A photoelectric recorder has been developed combining all the advantages of the direct-acting recorders with those of the most sensitive indicating instruments. This is accomplished by providing a separately excited recording element to do the actual work of making the records. A sensitive indicating instrument controls the position of the recording element, the only link between these two being a combined optical system and photoelectric circuit. As the only equipment placed on the shaft of the basic or indicating element is a galvanometer mirror, this element may be even more sensitive than the usual indicating instruments with pointers. Through a system of mirrors and photoelectric tubes the position of this mirror controls the position of the recording element which readily may possess as much torque and be as heavy and sturdy as desired without affecting the basic element or measured circuit in any way. In general, anything which can be indicated can be recorded continuously by means of the photoelectric recorder. It is self-compensating for all normal changes in supply voltage, lamp illumination, and pliotron and photoelectric tube characteristics, and is of an extremely high accuracy. **(A.I.E.E. Paper No. 32-15)**

6. General Electric Company, Schenectady, N. Y.

Interconnection of Primary Lightning Arrester Ground and Grounded Neutral of the Secondary Main

By C. F. Harding[7]
C. S. Sprague[7]

VARIOUS possible transformer connections and protective devices on standard 60-cycle overhead power and lighting distribution systems having 4,000-volt four-wire primaries and power and lighting secondary mains have been investigated over a period of years. Considerable information was furnished by an experimental line with an insulated artificial cloud charged to potentials up to 150 kv. by means of a surge generator. Among the conclusions reached are the following:

1. Efficient primary protection upon an overhead distribution system affords a considerable degree of protection to secondaries located below the primaries.
2. A well-grounded secondary neutral wire acts in reducing potentials on adjacent wires.
3. With existing transformer design, the insulation of the secondary winding may be considerably over-stressed by surges having steep wave fronts, without excessive stress on the primary insulation. Such secondary stresses may be relieved by improvements in secondary insulation.
4. Low ground resistances, although desirable in other respects, do not reduce necessarily the initial potentials which may be induced upon the system.
5. A non-inductive load in the consumer's premises reduces the potentials at the service entrance 60 to 70 per cent.
6. Tests have shown that the interconnection of primary lightning arrester ground to the grounded neutral of the secondary main effects a considerable reduction in voltages at the transformer and imposes no extra hazard upon the consumer's wiring. **(A.I.E.E. Paper No. 32-16)**

Field Studies of the Protection of Distribution Transformers By Lightning Arresters

By K. B. McEachron[8]
L. Saxon[9]

A COOPERATIVE field study with portable impulse generator and cathode ray oscillograph was made of the lightning protection of transformers connected to a 4.45-mile, 4,600-volt rural distribution circuit. The tests described were made with the pellet arrester. The results show that:

1. Although the arrester discharge voltage is but a fraction of the strength of the transformer, arrester ground resistances may be high enough not to protect the transformer if the usual connection to ground is employed. This results in either blown fuses or winding failure.
2. Interconnection of the primary arrester ground and secondary neutral gives a high degree of protection to the transformer from surges originating on either primary or secondary, regardless of the arrester ground resistance.

7. Purdue University, Lafayette, Ind.
8. General Electric Company, Pittsfield, Mass.
9. Utility Management Corporation, New York, N. Y.

3. With low resistance secondary grounds, such as water pipes, both lightning voltages and power voltages on the consumer's premises will be negligible in value, either with or without the above mentioned interconnection.

4. With interconnection it is believed that the possible hazard between separate grounds which now may exist on the consumer's premises, resulting from high resistance secondary grounds, will be greatly reduced. (**A.I.E.E. Paper No. 32-17**)

Protection of Distribution Transformers from Failure Due to Lightning

By
A. M. Opsahl[9]
A. S. Brookes[10]
R. N. Southgate[10]

USUAL methods of connecting arresters for the protection of distribution transformers often are inadequate, resulting in flashover of bushings or windings due to lightning, even though the arrester in itself is capable of protecting the transformer with a large factor of safety. Such flashover may be attributed to the fact that surge current flowing to ground through the ground leads of the arrester gives rise to inductive drop and resistance drop which add to the arrester voltage.

Improved protection of the transformer results from the connection of the arrester ground lead to the secondary circuit. The following methods limit the surge voltage across the bushing approximately to the characteristic crest voltage of the primary arrester, but differ in resulting secondary voltages:

1. Direct connection of a low resistance primary arrester ground to a grounded secondary neutral produces no higher voltages on the customer's service than are experienced when flashover occurs with the present protection schemes.

2. Connection of the primary arrester ground to the secondary neutral through a low voltage arrester gives substantially the same results as with the direct connection.

3. Connection of the primary arrester ground through two low voltage arresters to the secondary outside wires results in increased customer voltage. (**A.I.E.E. Paper No. 32-18**)

Studies in Lightning Protection on 4,000-Volt Circuits—III

By
D. W. Roper[11]

FOR A NUMBER of years accurate data regarding the causes of lightning failures on distribution lines in the Chicago district and the effect of various methods of reducing these troubles have been kept. For Chicago conditions it appears possible to reduce the total number of transformer troubles annually caused by lightning to less than one per thousand transformers installed, through the adoption of the suggestions below:

1. Use the four-wire three-phase system of distribution with grounded neutral.

2. Install lightning arresters at locations where transformers are connected to overhead primary mains, using low voltage arresters on the neutral wire and valve type arresters suitable for the "Y" voltage on the phase wires.

3. Use transformers having insulation on the coils and leads that will not deteriorate with age and which will withstand a transient voltage test safely above the voltages to which the transformer will be subjected in service when protected by the arresters.

4. If conditions warrant, install a second ground wire and connect it to a second ground rod.

5. Select newest transformers for installation in districts of low transformer density.

6. Require each customer to ground his neutral wire to a water pipe on his premises.

7. Connect the neutral wire of each section of secondary main to at least two ground rods; and on long mains install ground rod connections at intervals not exceeding 600 ft.

8. Where transformers are connected to primary mains 1,500 ft. or more distant from the next adjacent transformers, install on the pole about 600 ft. from the transformers the same lightning arrester equipment as on the transformer pole.

9. Install lightning arresters on all cable poles.

10. Ground the lead sheaths of all underground primary cables. (**A.I.E.E. Paper No. 32-19**)

Investigation of Lightning Protection for Distribution Transformers

By
T. H. Haines[12]
C. A. Corney[12]

A HISTORY is presented in this paper showing the results of lightning arrester protection for distribution transformers in New England, where the normal ground electrode resistance is much higher than in most other parts of this country. The general conclusions indicated by this study may be summarized as follows:

1. Experience has indicated that the application of lightning arresters to line transformers in areas affected by lightning reduces the trouble rate by about 50 per cent.

2. Variation in ground resistance within the values readily obtainable in this territory has slight effect upon the efficiency of the arrester.

3. The value of treating grounds or the installation of multiple grounds in an effort to lower resistance is questionable unless by so doing the resistance can be decreased to a value of approximately 100 ohms or less.

4. Insufficient electrical clearances in the smaller and older transformers are an important source of lightning trouble. Larger bushings, and greater clearances are clearly indicated as a necessary feature of correct transformer design. (**A.I.E.E. Paper No. 32-44**)

Distribution System Lightning Studies by Philadelphia Electric Co.

By
H. A. Dambly[13]
H. N. Ekvall[13]
H. S. Phelps[13]

INVESTIGATIONS of lightning troubles have been conducted since 1921 on the distribution system of the Philadelphia Electric Company, to determine the magnitude and nature of trouble in various localities, the effectiveness of lightning arresters under field conditions, and methods for improving service continuity. The conclusions may be summarized as follows:

1. About 5 per cent of the aerial distribution transformers annually experience trouble due to lightning, the small transformers being the more susceptible.

2. Lightning arresters were found to afford little benefit to transformers of 15 kva. and less, and substantial benefit to the larger sizes.

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10. Public Service Elec. & Gas Co., Newark, N. J.
11. Commonwealth Edison Company, Chicago, Ill.
12. The Edison Elec. Illum. Co. of Boston, Mass.
13. Philadelphia Elec. Co., Philadelphia, Pa.

3. The obtaining of reasonable conclusions required that all major factors influencing lightning trouble be considered and all data be reduced to a common basis.

4. Because of the many factors involved, it has not been possible to determine thus far whether there is a material difference between the susceptibility to lightning trouble of grounded and ungrounded systems.

5. Low ground resistance may be obtained at low cost by connecting the arrester ground wire to the secondary circuit grounded neutral.

6. Customer interruptions from trouble on the primary system far exceed those from trouble on the secondary system.

7. The number of customer interruptions of less than 5 min. greatly exceeds the number of those of more than 5 min.; however, based on customer-hour interruptions, the order is reversed.

8. The major number of customer-hour interruptions due to all causes occur during electrical storms. At least one-half of these are attributable directly to lightning disturbances.

9. Lightning protection of distribution systems has been found to be of major importance from the standpoint of improving service continuity. **(A.I.E.E. Paper No. 32-20)**

Equivalent Circuits

By F. M. Starr[6]

EQUIVALENT circuits have been used from time to time in the solution of various magnetic and electrical problems. They have been found valuable in that they clarify the problem, simplify the analysis, and provide a means of replacing magnetic coupling with pure impedance links, thereby permitting the use of the calculating board for solution.

A particular problem has prompted a new study of representing a system of coupled circuits by an equivalent composed of pure impedance links. This problem arose primarily through the difficulty of representing adequately on the calculating board, groups of parallel transmission lines in which zero phase currents were flowing. In order to represent such a group on the calculating board it is necessary to replace the group with an equivalent circuit in which mutual impedance between the lines is simulated by pure impedance links. Closely related to the problem of coupled circuits is the general network problem.

In the present study the general equivalent mesh for the n-winding transformer is derived, as well as that for the mesh equivalent of the general network having $m + 1$ points of entry. These provide a background for the study of system networks involving groups of parallel transmission lines in such a manner as to simplify the problem greatly. These methods are perfectly general and may be applied to many other problems. **(A.I.E.E. Paper No. 32-21)**

Transient Oscillations of Mutually Coupled Windings

By L. V. Bewley[8]

IN THE PAST, the mathematical analysis of transient oscillations in transformer windings has been based upon a single winding having self and mutual inductances between its turns, capacitances along the stack and to ground, and, in one instance, resistances representing the losses. Such a circuit ignores the presence of secondary circuits, but strangely enough proves adequate to describe the internal high frequency transients of the winding under consideration, not only qualitatively but quantitatively as well. Cathode ray oscillograms, however, do show some difference in the characteristics of the oscillations, depending upon the terminal connections of the secondary circuit. Also, there is nothing in the single winding theory of transformer oscillations relative to the internal oscillations of the secondary circuit.

A mathematical study has been made of the oscillations occurring in the mutually coupled primary and secondary windings of a transformer when one of the terminals is subjected to the impact of a traveling wave. Solutions for grounded and open terminal conditions are obtained, but the general solution for any impedances at the terminals is not attempted, except for the initial distribution. **(A.I.E.E. Paper No. 32-4)**

Geometrical Circuits of Electrical Networks

By R. M. Foster[14]

IF ALL THE ELECTRICAL properties of a given electrical network are abstracted, there remains a geometric circuit completely characterized by the sets of branches terminating at the various vertexes. The use of such geometric circuits in place of the networks is desirable in the solution of a number of different problems. A successful application of this method requires to start with a complete enumeration of all distinct circuits classified according to certain specified properties.

In the present study enumerations of geometric circuits have been made, classified according to two different parameters, the nullity (number of branches minus number of vertexes plus number of separate parts) and the rank (number of vertexes minus number of separate parts). The geometric circuits which are symmetrical with respect to all branches and all vertexes, also have been listed. **(A.I.E.E. Paper No. 32-22)**

The Breakdown of Glass With Alternating Potentials

By N. D. Kenney[15], A. M. Luery[16], J. D. Moriaty[17]

THE FAILURE of solid dielectrics does not take place by one mechanism of breakdown but by several, different laws governing each type of failure. For some time thermal breakdown has been established as one of the mechanisms of puncture, and in 1928 there was found a type of breakdown in which the potential gradient is independent of temperature and thickness. This latter was spoken of as in the disruptive region. In 1929 a third type of breakdown was found lying between the previous two, and was termed as in the intermediate region.

These former experiments were conducted with direct potentials and additional experiments have been made recently to determine the results with alternating potentials. Glass was used as the test material.

It was demonstrated that three distinct regions of breakdown are obtained with alternating current, similar to those with direct current. In the disruptive and intermediate regions, it was found that breakdown occurs at an alternating peak voltage approximately equal to the direct breakdown voltage, while in the thermal region breakdown occurs at an alternating peak voltage somewhat lower than the direct breakdown voltage. **(A.I.E.E. Paper No. 32-23)**

14. American Tel. & Tel. Co., New York, N. Y.
15. Mass. Institute of Technology, Cambridge, Mass.
16. N. J. Bell Telephone Co., Newark, N. J.
17. Bell Telephone Laboratories, Inc., New York, N. Y.

The Predetermination of the A-C. Behavior of Dielectrics

By J. B. Whitehead[5] A. Banos, Jr.[5]

CHARGE and discharge currents of any type of dielectric under continuous potential make it possible to predict accurately the loss, power factor, and capacity at 60 cycles. This is done by an empirical determination of the equation for the relaxation function of the dielectric at a given temperature, followed by the application of von Schweidler's method. The method developed is available at any frequency, provided the continuous potential charge and discharge currents may be measured over initial time intervals comparable with the alternating period.

A convenient and sufficient expression for the relaxation function is shown in this paper to be a sum of three exponentials. Further, experiment and analysis prove that the method of three exponentials predicts accurately the a-c. behavior of a dielectric at 60 cycles. The usual forms of irreversible conduction encountered also are defined and classified. The case in which the initial constant current does not obey Ohm's law has been considered analytically as regards its contribution to the a-c. behavior. (**A.I.E.E. Paper No. 32-45**)

Radio Interference from Insulator Corona

By F. O. McMillan[18]

PUBLISHED in full in this issue of ELECTRICAL ENGINEERING, p. 3-9. **Pamphlet copies not available.**

Relationships Among the Magnetic Properties of Magnet Steels and Permanent Magnets

By K. L. Scott[19]

OPEN CIRCUIT remanence of magnet steels is the magnetic induction at the magnetic equator of a permanent magne; with no external magnetizing or demagnetizing force. A new relationship has been found connecting the open circuit remanence of a permanent magnet with the factors determining its value. By plotting the ratio of remanence to residual induc-ion as the ordinate, and using as the abscissa the ratio of the product magnet lengths times square root of coercive force to the product of equivalent diameter times the square root of residual induction, a curve is obtained which appear: to be general and valid for all kinds of magnet steel.

Various quantities have been proposed for use as criteria of the magnetic quality of magnet steel, the quantity having the greatest theoretical justification being the maximum value of the product of the coordinates of the demagnetization curve for a given field, where the demagnetization curve is the portion of the hysteresis loop between residual induction and coercive force. Experimental justification of the validity of this criterion has been secured. However, it is approximated by the product of residual induction and coercive force, and as this latter quantity can be determined with less effort, it is preferable for routine use. (**A.I.E.E. Paper No. 32-24**)

18. Oregon State College, Corvallis, Ore.
19. Western Electric Company, Inc., Chicago, Ill.

Auxiliary Drives for Steam Power Stations

By F. H. Hollister[20]

ESSENTIALLY the full content of this paper is published in this issue of ELECTRICAL ENGINEERING, p. 20-1. **Pamphlet copies not available.**

Steam Driven Auxiliaries for Power Plants

By W. P. Dryer[21]

ESSENTIALLY the full content of this paper is published in this issue of ELECTRICAL ENGINEERING, p. 21-5. **Pamphlet copies not available.**

Electrically Driven Auxiliaries for Steam Power Stations

By L. W. Smith[20]

ESSENTIALLY the full content of this paper is published in this issue of ELECTRICAL ENGINEERING, p. 25-8. **Pamphlet copies not available.**

Proposed Definition of Terms Used in Power System Studies

By H. K. Sels[10]

THE INSTITUTE'S subject committee on definitions has submitted its report on terminology for power system interconnection and stability studies. The report covers the five following general divisions: interconnection terms, stability terms, active power and reactive voltampere conventions, synchronous machine quantities, and response of excitation systems. In preparing its report the committee has reviewed technical literature and consulted representatives of members of various A.I E.E. committees.

The definitions presented are descriptive and cover the field practically in its entirety. While many of these may be considered arbitrary, they have been chosen in the best interest of the profession. Their general adoption will lead to a better mutual understanding with less possibility of confusion and controversy on technical questions. (**A.I.E.E. Paper No. 32M2**)

Experience with Electrical Stability of Conowingo Station of Philadelphia Electric Co. System

By R. A. Hentz[13] J. W. Jones[13]

A BRIEF description of the Philadelphia Electric Company system with particular reference to the features influencing stability of the Conowingo hydroelectric station is

20. Sargent and Lundy, Inc., Chicago, Ill.
21. Stone and Webster, Inc., Boston, Mass.

iven in this paper. It summarizes the various calculations and ests associated with the stability problem, and presents a record f operating experience from a stability standpoint during four ears of service.

Several cases of instability due to line faults have occurred. thorough study of the matter was undertaken and as a consequence changes were made in the equipment and system set-up, nvolving the development and installation of higher speed ircuit breakers and relays.

Detailed records are given for all faults on those parts of the ystem intimately associated with the Conowingo development. These records show the improvement in stability obtained by the hanges in the system and indicate attainment of a generally atisfactory condition. (**A.I.E.E. Paper No. 32-25**)

Generalized Stability Solution for Metropolitan Type Systems

By
S. B. Griscom[2]
W. A. Lewis[2]
W. R. Ellis[2]

STABILITY studies of metropolitan type systems nay be profitable not because instability has been a serious operating problem, but because such studies often may permit more reliable or economical layouts to be utilized safely. A simplified method for determining the degree of stability of any layout of a metropolitan type system is presented in this paper.

General stability curves are given by means of which the ransient stability during faults may be determined. The results re obtained as the permissible fault duration in terms of certain ndexes of the system and fault. For a particular fault these ndexes may be found from a short-circuit study made on a d-c. alculating board or its equivalent; only three readings are equired to obtain the result. (**A.I.E.E. Paper No. 32-26**)

An Induction Motor with Paralleled Rotor and Stator

By
A. G. Conrad[24]
R. G. Warner[24]

A LITTLE known method of operating induction notors is to parallel the rotor and stator windings. When his is done the pull-out torque as a motor is approximately loubled and the continuous horsepower output may be increased; s an induction generator, the maximum kva. output is increased. The machine may be operated simultaneously as a motor and as a enerator. For heavy loads the efficiency is higher than that of he same motor operated with its sliprings short-circuited; and f the motor is to operate over a wide range, maximum efficiency nay be secured by using a switching arrangement to short-circuit he rings at light load.

By paralleling the rotor and stator windings the rating of a iven motor may be increased, the initial cost of a motor required o drive a given load will be less, and the no-load losses may be nade smaller. If the ratio of stator to rotor currents is other than pproximately 1:1, the windings may be paralleled through an uto-transformer. This should improve performance, since the ransformer will by-pass part of the low frequency current that rdinarily would flow through the supply transformers. Tests on a machine with rotor and stator paralleled directly, indicated wo disadvantages: the machine was noisy and the exciting urrent was high. This, however, might be eliminated by special lesigning. (**A.I.E.E. Paper No. 32-27**)

24. Yale University, New Haven, Conn.

Some Considerations in the Design of Damper Windings For Synchronous Motors

By
C. C. Shutt[2]

EXTENSION of the application of synchronous motors to include more specialized fields requires that the design of damper windings for special starting performance become a more exact art. Possibilities and limitations in the performance which may be obtained by variation of the damper winding design are brought out by classification of the various types of these windings.

Damper windings may be classified arbitrarily as low reactance and high reactance types. The low reactance windings include those made up of round or rectangular bars of such size that skin effect has only a negligible influence upon the distribution of the current in the bar. These windings are well suited to give a high ratio of torque to kva., especially during the initial part of the starting period. Many other types of performance including fairly uniform torque over the starting period, or a low starting torque with high pull-out torque or a relatively low kva., can be obtained with high reactance windings. These include all forms of double-deck windings as well as bars which are subject to appreciable skin effect; also single-deck windings, the characteristics of which change noticeably as the motor comes up to speed. (**A.I.E.E. Paper No. 32-28**)

Power Losses in Electrolytic Condensers

By
F. W. Godsey, Jr.[26]

ELECTROLYTIC condensers on a-c. circuits have higher power losses than would be expected from the leakage currents and electrolyte resistances. Likewise, losses change with the applied voltage, temperature of the cell, the frequency of the applied voltage, and with external circuit conditions governing current wave shape in such ways that it is almost impossible to predict results in advance. When a sine wave of voltage is impressed the current wave usually contains large harmonics, indicating a non-linear function in the impedance of electrolytic condensers. Increases in voltage, temperature, frequency, and concentration of the electrolyte also cause increases in the harmonics in the current wave.

A film on the anode surfaces saturated with the electrolyte solvent would explain the characteristics as measured and also make it possible to predict characteristics with some accuracy. Ion penetration of the outer regions of the film, and a comparatively continuous film near the anode, explain the non-linear characteristics. The variation of the electrolyte potential can be predicted on this basis, and power losses also are more easily predictable. (**A.I.E.E. Paper No. 32-30**)

Film Characteristics of Electrolytic Condensers

By
F. W. Godsey, Jr.[26]

ELECTROLYTIC condensers of the film forming type have some interesting characteristics which have never been satisfactorily explained. Extremely thin oxide or hydroxide

26. Safety Car Heating & Lighting Co., New Haven, Conn.

films, formed on the surface of the metal anodes, seem insufficient in themselves to explain the complete action. Likewise, an electromotive equilibrium is insufficient to explain the action.

Electrolytic condensers with extremely low applied voltages show large variations in measured capacity from high voltage measurements. The results indicate a film in which ion penetration plays a large part. Assuming the presence of a film saturated with water as the dielectric overcomes a number of former obstacles and lessens the necessity for the very thin films formerly assumed. (**A.I.E.E. Paper No. 32-31**)

Electrical Precipitation

By A. W. Simon[27] L. C. Kron[27]

COTTRELL treaters have found many applications in various industries for the recovery or removal of smoke, dust, and fume particles from their containing gases. Precipitation efficiency, or percentage removal, depends upon a number of fundamental variables. A study made of these factors has placed the process on a more quantitative basis than formerly was possible.

Experiment shows in general that the precipitation efficiency increases with the treatment time, voltage, current, and power, according to a curve which partakes of the nature of that for a condenser charge; in other words, the relationships are exponential, and the cleaner a gas becomes the harder it is to remove more particles from it. The value of operating voltage above that necessary to produce corona was found to have little effect upon the cleaning efficiency, but the current flowing between electrodes and through the gases within the precipitator is of considerable importance to efficiency. (**A.I.E.E. Paper No. 32-32**)

Commutation Considered As a Switching Problem

By R. E. Hellmund[2] L. R. Ludwig[2]

THE USUAL commutation theories deal with the reversal of the current in the commutating coil and with means for bringing about such reversal either along a straight line or curve. The principal object in such studies is to accomplish commutation without excessive current densities under the brush. Frequently, however, it is impossible to realize this, and the phenomenon which results is essentially one of switching. With this new concept in mind, factors may be studied which previously have not been considered.

For example, the mutual and self-inductance of the windings and their capacity may have an effect upon the energy to be dissipated during commutation. With this concept of switching in mind it can be seen that there may be a difference in commutation between shunt, series, or separately-excited machines, and with laminated or solid field structures, although the speed, current, and commutating fields are the same. Also, a-c. commutator machines may be affected by the transformer to which the machine is connected. Interesting results are obtained with two series-connected motors on a motor car, especially in a-c. motors having no damping effects in their field structure. During certain conditions each motor may have an effect upon the commutation of the other; this is explained readily by the switching theory. In general, the commutating phenomena cannot be considered as analyzed completely unless the possibilities of the switching phenomena as influenced by the various connected circuits have been given due consideration. (**A.I.E.E. Paper No. 32-33**)

27. Tennessee Coal, Iron & Railroad Co., Birmingham, Ala.

Equalizing Currents in the Armature of a D-C. Machine

By R. M. Baker[2]

WHEN THE PARALLEL type winding was first used on the armatures of large d-c. machines, it was almost impossible to obtain sufficiently good magnetic balance of the main field circuits to permit satisfactory operation. In 1896 the idea was conceived of automatically balancing the flux in the main poles by connecting together those points on the armature which normally should be of the same potential. These equalizing connections have proved themselves capable of taking care of considerable unbalance in the same field; in fact their performance has been so satisfactory that little study has been given to the details of this action.

An increased knowledge of the behavior of these currents, however, has been secured by an analysis which is unique in that it is based upon experimentally determined curves of variation in equalizing current in an actual machine. The analysis shows definitely how these currents act to correct the unbalance causing their flow. It was found that even with very small inequalities of the main pole gaps the equalizing current in an armature coil may reach a peak value as high as 25 per cent of the full load coil current, several times each revolution of the armature. It has been shown also that the oscillograph is very useful in studying the behavior of equalizing connections, and that empirical results are obtainable without much difficulty. The securing of similar relations by an analytical method would be very complex. (**A.I.E.E. Paper No. 32-5**)

Calculation of No-Load Damper-Winding Loss in Synchronous Machines

By E. I. Pollard[2]

THE NON-UNIFORM nature of the air-gap due to the presence of alternate teeth and slots on the stator of synchronous machines results in a non-uniform distribution of flux density at the surface of the rotor. These pulsations in the air-gap induction produce pole-face loss. When a damper winding is present the pulsations link the damper bars producing circulating currents causing an additional loss which is designated by the term "no-load damper winding loss." The magnitude of this loss is found to vary from practically zero to as much as eight times the pole-face loss, or to as much as half of the total no-load core loss. A method now has been developed for calculating the no-load damper loss, based on theoretical considerations.

This study has indicated several ways by which the damper loss may be minimized. Changes in design to reduce pole-face loss also generally decrease the magnitude of damper loss, but the requirements in fundamental proportions of the machine usually require that these changes should not be made. The reduction of loss may be secured by keeping the number of bars on the machine and the bar resistance low. Perhaps the most powerful method of reducing loss is by adjustment of the ratio of rotor slot pitch to stator slot pitch. (**A.I.E.E. Paper No. 32-34**)

Sine Wave Generators

By L. P. Shildneck[6]

CERTAIN applications, particularly testing, require a sine wave of generator voltage under all load conditions, and the round-rotor type of sine wave generator consequently was developed. The stator is similar to that of a salient-pole machine but for the field a round punched rotor is used with a double layer winding distributed in evenly spaced slots.

A comparison of various types of these windings shows that three newly developed connections called the *X*, *U* and *W* types are superior to the old *V* and *Y* types, in that 15 per cent or more increase in output can be secured from the rotor without increasing the maximum coil temperature rise or impairing the voltage wave shape. This change is wrought by eliminating the undesirable features of the old types; namely, too few active coils in the *V* type, and unequal leg heating in the *Y* type.

The analysis made in this connection is quite general and directly applicable to all round-rotor synchronous machines with double layer rotor coil windings as exemplified by sine wave generators and also synchronous induction motors. By selection of the proper connections any one of the factors desired, wave form, efficiency, and heating, can be stressed to any desired degree. (**A.I.E.E. Paper No. 32-35**)

Engineering Features of Three-Power Locomotives

By F. H. Brehob[28] F. H. Craton[28]

AN ARTICLE based upon this paper is contained in this issue of ELECTRICAL ENGINEERING, p. 9-13. **Pamphlet copies not available.**

Motors for 3,000-Volt D-C. Multiple Unit Cars

By J. C. Aydelott[28]

A NEW MULTIPLE unit car motor incorporating many novel features of design was developed for the electrification of the suburban service of the Delaware, Lackawanna & Western Railroad, the first installation of multiple unit suburban service in this country employing a trolley potential of 3,000-volts direct current. The absence of trouble in commencing and maintaining service marks the whole electrification program.

There now are 564 of these motors in service on the Lackawanna railroad, and between August 1930 and June 1, 1931, 4,500,000 car miles have been operated with only two train delays chargeable to motor failure. During the period of initial operation the motors have been remarkably free from flashovers, insulation failures, and mechanical troubles. This preliminary operation indicated also that the maintenance expense will be unusually low. The securing of the many desirable features in motor design, and the consequent successful operation, may be attributed largely to the development of new design features. (**A.I.E.E. Paper No. 32-36**)

28. General Electric Co., Erie, Pa.

Temperature Rise of Ventilated Railway Motor Armatures

By D. A. Lightband[2]

THE CALCULATION of temperature rise and of time-temperature curves of a railway motor for which only preliminary design data are available, usually presents considerable difficulty. Modern railway practise demands increasingly large power units in a limited space, so that accurate methods are necessary for the predetermination of temperature rise. This must be used as a basis for guaranteed ratings and time-temperature curves in the application of a motor to a complicated service cycle.

Equations derived from the usual theory of heat flow between related bodies give a method for calculating the temperature rise of the armature in a new design of motor, for any time interval and load condition. Consistent results are given when applied to motors of widely varying size. By making certain assumptions the armature can be reduced to a simple equivalent model consisting of two conducting bodies separated by an insulating wall, and equations resulting from an analysis of this thermal system form a practical method of calculating time-temperature curves of an armature from preliminary design data. (**A.I.E.E. Paper No. 32-7**)

Preparing Substations for Electric Operation

By L. B. Curtis[29]

APPROXIMATELY forty substations are involved in the extensive electrification program recently announced for the Pennsylvania Railroad between New York and Washington; eleven of these already are in operation. A definite program for testing these substations before they are placed in operation has been evolved, and this procedure has been combined into a single set of test instructions.

The tests are separated into three groups: (1) preliminary tests without d-c. control or a-c. power; (2) tests with d-c. control but without a-c. power; and (3) tests with d-c. control and a-c. power. These test instructions are unusually complete and cover all possible sources of error which might interfere with the successful operation of the substation when it is placed in service. (**A.I.E.E. Paper No. 32-37**)

The Time Services of the U.S. Naval Observatory

By J. F. Hellweg[31]

ONE HUNDRED and one years ago the Naval Observatory was created. Since then it has had the determination and broadcasting of the nation's time. This is broadcast in mean solar time although kept in sidereal time. Measurement of time is based upon the earth's rotation and is very accurately observed and calculated. Observations are made by transit instruments with which the successive transits of predetermined stars are observed.

Because of its increasing importance in the nation's daily life great accuracy is demanded of the time service, and means of increasing this accuracy constantly are being sought. A new

29. Pennsylvania Railroad, Philadelphia, Pa.

31. U.S. Naval Observatory, Washington, D. C.

clock vault now is nearing completion. It will contain precision timepieces maintained at constant temperature and pressure at all times. The new clocks now are under construction and it is hoped that with this equipment, and modifications which are being planned, it will be possible to extend the time service, increase its accuracy, and add to the number of broadcasts per day. (**A.I.E.E. Paper No. 32-38**)

Time Services of the Telegraph Companies

By G. W. Janson[32]

THREE CLASSES of time service are distributed by the telegraph companies. The first of these, commonly known as "noon beats" comprises the transmission during a three-minute period ending at noon eastern standard time of a series of electrical impulses originating from the naval observatory at Washington, D. C. This service is used very largely for correcting local master clocks throughout the United States once each day. The second time service commonly known as "jewelers' beats" comprises a similar transmission throughout the day of a series of coded impulses distributed in each locality by a master clock. These beats are used principally by jewelers for regulating timepieces.

The most extensive distribution of correct time by the telegraph companies is the automatic correction of clocks. The Western Union Telegraph Company's synchronizing system corrects about 120,000 clocks of which 95 per cent are rented to subscribers. These clocks operate independently but are reset to the correct time each hour by the telegraph synchronizing service. (**A.I.E.E. Paper No. 32-39**)

Synchronous Electric Time Service

By H. E. Warren[33]

PREVIOUS to 1916 no commercial a-c. system was regulated with sufficient accuracy of speed to enable its use for indicating time. Two devices then were developed making commercial a-c. time service possible. The first of these was a self-starting synchronous motor which utilized residual magnetism to enable the rotor to start and run at synchronous speed. The second consisted of an indicating instrument which would show to a generating station operator, directly in terms of time, deviations of average frequency from standard.

About 1928 several new varieties of synchronous motors suitable for use in clocks were developed. These may be divided into two classes, and self-starting and non-self-starting. The latter generally has toothed soft steel rotors, while the self-starting motors utilize a-c. fields with rotating components brought about by the use of shading coils. Both types now have been developed to require small power input and to eliminate hum. These are now being applied to many timing devices other than clocks.

The standardization of average frequency is of great value to the power companies in many ways other than the furnishing of time services. Further increase in the accuracy of control is to be expected from the use of automatic frequency control equipment which now is being developed. (**A.I.E.E. Paper No. 32-40**)

32. Western Union Telegraph Co., New York, N. Y.
33. Warren Telechron Company, Ashland, Mass.

New Key West-Havana Carrier Telephone Cable

By H. A. Affel[14], W. S. Gorton[18], R. W. Chesnut[18]

A NEW SUBMARINE cable was laid recently between Key West and Havana to furnish increased telephone facilities between the United States and Cuba. This is the longest deep sea telephone cable in existence and also is unique in being the longest telephone cable circuit without intermediate repeaters and without inductive loading. The new cable operates at frequencies up to about 28,000 cycles per second; it has a single central conductor with concentric tape return, and employs the newly developed material paragutta for insulation. Due to the smaller dielectric constant and to the smaller leakance, the cable is much smaller in size than any of the three other cables between these countries.

A carrier telephone system provides three telephone channels and as ultimately developed, a still greater number of facilities may be made available. A large number of noise sources was investigated and the necessary methods for eliminating these were installed.

The Development of a Handset for Telephone Stations

By W. C. Jones[18], A. H. Inglis[14]

A NUMBER of factors contribute to the difficulties involved in the design of a telephone handset which gives as good service performance as a deskstand. The handset transmitter for example not only is used in a wider range of positions but also is moved much more frequently, so that wider variations are experienced in its characteristics. The more severe use to which the handset is subjected requires special design measures to prevent an appreciable shortening of useful life.

Further difficulties are introduced by the close physical connection of the receiver and transmitter, in that "howling" tends to be set up. Also, the distance between the receiver and transmitter must be such as to be convenient for the user without introducing unnecessary losses in voice transmission in air.

The handset has been developed so that it overcomes all these difficulties and is interchangeable with the deskstand in existing telephone plant without important reaction on either transmission or signaling performance. That the design meets the wishes of the public is evidenced by the steady increase in demand to more than 1,000,000 sets per year at the present time.

An Automatic Concentration Unit for Printing Telegraph Circuits

By G. S. Vernam[34]

WHEN a number of lightly loaded telegraph circuits terminates at a central telegraph office, and the number of messages over each circuit is insufficient to keep the operator fully employed, these circuits usually are grouped together on a switchboard or "concentrator," so that a single operator can send and receive messages over any line of the group.

Printers or "teletypewriters" of the so-called "start-stop" type are being used to a large and increasing extent on such

34. International Communications Laboratories, New York, N. Y.

lightly loaded circuits, both by the telegraph companies and by private customers. As a result, concentration units are being used to an increasing extent for printing telegraph circuits.

Manually operated telegraph concentrators have been in use for many years, but an automatic concentrator now is being employed to permit the individual printer operators to set up their own connections. Outward calls are established by dialing without requiring multiple turrets or switching operators, and inward calls to idle positions can be established automatically without the delay involved in manual switching operations. Step-by-step automatic switches and calling dials are used, a number of special features being included.

Carrier Application to a Telegraph Plant

By
R. E. Smith[34]
L. A. Kelley[34]

THE REQUIREMENTS for carrier systems in telegraph plants differ somewhat from those in telephone plants. Primarily these differences are due to the fact that telegraph plants are based upon the wide use of d-c. telegraph circuits which can be operated fairly successfully on a ground return basis. Furthermore, the operating energy levels of the various circuits on the same lead are not restricted by the presence of other types of communication circuits occupying a frequency transmission range other than that required for d-c. telegraph signals. Other equally important factors enter into the problem, and are outlined in this paper.

A description also is given of the transmission and equipment features of the system recently developed to meet the specific needs of the Postal Telegraph-Cable Company. The system is now in commercial service in the extensive open-wire plant of this company. Performance characteristics showing the capabilities of the system also are included.

Forces of Electric Origin in the Iron Arc

By
F. Creedy[35]
R. O. Lerch[35]
P. W. Seal[35]
E. P. Sordon[35]

A NUMBER of phenomena are present in overhead arc welding, for which no adequate explanation has been possible. Among the questions are: (1) what is the force that causes the molten drop to travel across the arc face from the electrode to the work, (2) why is it that the drop is detached with explosive violence rather than gradually? In an attempt to determine the electric origin of these forces in high current metallic arcs, the magnified image of an arc was projected on a screen by means of a lens. In this manner, relations between the electrical forces, arc currents, and arc lengths were studied.

General conclusions may be drawn from these results indicating that the force which detaches the globule from the welding rod may depend upon the "pinch effect" due to the magnetic field tending to force the outer portions of a conductor toward the center. As the cross-section of the area between the globule and the electrode becomes smaller, the pressure is increased as the square of the current density. The force tends to sever the part still attached. This appears to be the cause of the explosive violence with which the globule is detached. It appears that as soon as the globule is separated it is carried over by the force of the reaction resulting from the emission of minute particles at high temperature. (**A.I.E.E. Paper No. 32-41**)

35. Lehigh University, Bethlehem, Pa.

An Improved A-C. Arc Welder

By
A. M. Candy[2]

THE COST OF APPARATUS for arc welding with the a-c. arc is less than that for the d-c. arc. In spite of this the d-c. arc has been used much more extensively because: the open circuit voltage of the a-c. welder was about double that of the d-c. equipment with a consequent increased life hazard; the a-c. arc was much more difficult to strike and hold; and it also drew a low power factor current from the line.

By imposing a high frequency on the welding circuit all these disadvantages of the a-c. arc welder have been overcome. The voltage developed by the oscillator circuit is sufficiently high to start the discharge in the arc just before the electrode contacts the work; for this reason the arc starts easily, sticking of the electrode to the work is eliminated, and a lower voltage may be used for the basic frequency arc. The necessity for a high leakage reactance to throw the voltage and current out of phase so as to maintain the current when passing through zero is eliminated. Consequently the power factor is considerably improved; in fact it is approximately 90 per cent, which is even better than that of an induction motor driving a d-c. generator for d-c. welding.

The quality of the weld made with this improved a-c. welder is equal in every respect to that of d-c. welds. Because of the low no-load losses, the low investment charges, and low maintenance costs resulting from the absence of any rotating parts, the a-c. welding equipment is very economical to operate especially when welding materials of 16 gage or less. (**A.I.E.E. Paper No. 32-42**)

Recent Developments in Design of Arc Welding Generators

By
K. L. Hansen[36]

A DROOPING volt-ampere characteristic is required of an arc welding generator in order to overcome the instability of the arc due to its negative resistance characteristic. Where there are abrupt changes in the arc resistance, as in metallic arc welding, this requirement becomes complex and exacting. Other desirable design features are as follows:

1. Elimination of the external reactor sometimes used to smooth out current fluctuations.
2. Reflection of current impulses in the main circuit back into the field to quicken field flux changes and thereby make the machine more responsive to changes in the external resistance.
3. Elimination of the exciter without resorting to the two-pole armature four-pole field structure.
4. Elimination of all regulating rheostats and switches without interfering with the desirable characteristics of the generator.

In a new completely self-contained arc welding generator, the first two of the objects enumerated above have been obtained by a novel design of the commutating winding, shunt windings, and main poles, and by adding a special winding consisting of one turn short-circuited upon itself. Suitable excitation is secured by two sets of auxiliary brushes spaced from 50 to 60 electrical degrees ahead of the main brushes. Adjustment of the brushes enables the current to be varied. The resultant machine is very fast in response to variations in external resistance, and retains over a wide range of operation the characteristics desired in an arc welding generator. (**A.I.E.E. Paper No. 32-43**)

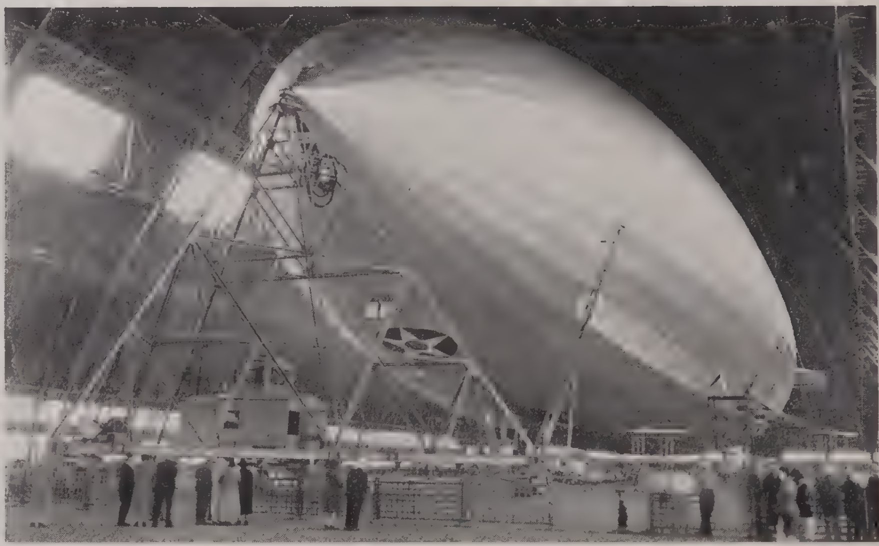
36. K. L. Hansen Engg. Co. Inc., Milwaukee, Wis.

News
Of Institute and Related Activities

Winter Convention Arrangements Completed

Fourteen Technical Sessions and Other Features Offered

EVERYTHING is in readiness for the 1932 A.I.E.E. winter convention which will be held with headquarters in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., January 25-29. An excellent schedule of events embracing fourteen technical sessions, a variety of inspection trips and social functions, and a special program for women guests has been completed.



The U.S.S. Akron "riding at anchor" in the Lakehurst, N. J. "dock"

Technical Sessions

Three of the technical sessions comprise important symposiums: (1) distribution circuit lightning protection, (2) system stability, (3) time and time services. Lightning as it is related to transmission lines has been treated often, but relatively little has been brought forth on the subject of distribution circuit lightning protection. Consequently this session should fill a gap in this field. System stability and its intricate relations when systems are interconnected offer a timely topic of interest to many groups. Valuable data and experience gained in this particular field will be brought out through the cooperation of manufacturing and operating companies. Likewise the symposium on time and time services will present valuable and interesting information on this modern phase of the art. With eleven other specialized sessions the program leaves little to be desired from a standpoint of technical interest.

Detailed information concerning this convention was published on p. 971-2 of Electrical Engineering for December, 1931. Additional information and a few minor changes are outlined in the following paragraphs.

The session on research which formerly was scheduled for Tuesday afternoon will be held on Wednesday morning in parallel with the symposium on stability. The first paper formerly listed in the session on research "Some Fundamental Theory and Experiments on Electrical Precipitation" by A. W. Simon and L. C. Kron, will be presented Thursday morning in the electrochemistry-metallurgy session.

The selected subjects session will be entirely devoted to a symposium on steam power station auxiliary drives.

A paper "Preparing Substations for Electric Operation" by L. B. Curtis, Pennsylvania Railroad, has been scheduled for presentation in the session on transportation.

John Fritz and Edison Medals

Two of the most highly prized rewards for engineering accomplishments will be presented in the Engineering Auditorium on the evening of Wednesday, January 27.

The Edison Medal will be presented to Dr. Edwin Wilbur Rice, Jr., for his contributions to the development of electrical systems and apparatus and his encouragement of scientific research in industry.

The John Fritz Medal will be presented to Dr. Michael Idvorsky Pupin for his accomplishments as a leading scientist, engineer, and author, and as inventor of the tuning of oscillating circuits and the loading of telephone circuits by inductance coils.

Details of the award of the John Fritz Medal were published in Electrical Engineering, Nov. 1931, p. 911. Details of the award of the Edison Medal are published on p. 61 of this issue.

Entertainment Features

A buffet supper (served by Louis Sherry) and smoker with entertainment will be held in the headquarters building on Tuesday evening, January 26. This informal occasion affords a splendid opportunity to renew old acquaintances and to make new ones. Tickets will be \$3 per person.

The dinner dance, for many years an outstanding social event of the Institute, will be held in the Grand Ballroom of the Hotel Astor, Thursday evening, January 28. Tickets will be \$6 per person. Reservations may be made in advance for tables seating eight or ten people.

For women guests a specially planned program has been arranged by the ladies' entertainment committee under the chairmanship of Mrs. E. B. Meyer.

On Wednesday, January 27, 6:30 p.m.,

graduates of Columbia University will dine at the Columbia University Club, 4 West 43rd Street, in an informal get-together dinner which will finish in time to enable them to attend the regular evening session. Price $1.50. For reservations address A. D. Hinckley, Columbia University.

Register in Advance

Each member should register in advance by mail, thus permitting the committee in charge to have the badges ready, saving time and reducing congestion at the registration desk. A card for this purpose was included in the mailed announcement.

Reservations for hotel accommodations should be made by writing directly to the hotel chosen. Rates for some of the hotels were listed in the mailed announcement.

Revised Schedule of Events

Monday morning and evening have been left open for committee meetings. Capital letters A, B, etc., denote technical sessions.

Monday, January 25

10:00 a. m. Registration
2:00 p. m. Opening of Convention
A—Protective Devices
B—Instruments and Measurements

Tuesday, January 26

10:00 a. m. C—Symposium on Distribution Circuit Lightning Protection
D—General Circuit Theory
2:00 p. m. E—Selected Subjects
6:00 p. m. Buffet Supper and Smoker

Wednesday, January 27

10:00 a. m. F—Symposium on System Stability
G—Research
1:15 p. m. Inspection Trips
2:00 p. m. Board of Directors Meeting
8:30 p. m. Edison Medal and John Fritz Medal Presentations

Thursday, January 28

10:00 a. m. H—Electrical Machinery
I—Electrochemistry and Electrometallurgy
2:00 p. m. J—Electrical Machinery
K—Transportation
7:30 p. m. Dinner Dance

Friday, January 29

10:00 a. m. L—Symposium on Time and Time Services
2:00 p. m. M—Communication
N—Electric Welding

Inspection Trips

Attention of all of those who will attend the convention is called to the fact that members of the inspections trips committee will be pleased to assist in the making of necessary arrangements for the visiting of neighboring plants or other points of special interest. The committee asks that members make known their desires as soon as possible after arrival.

U.S. Naval Air Station and U.S.S. Akron

The great Navy dirigible *U.S.S. Akron*, the building of which was started November 7, 1929, and completed August 8, 1931, when it was christened by Mrs. Herbert Hoover before approximately 150,000 people, now is stationed at the Naval Air Station at Lakehurst, N. J. The committee has arranged for an inspection of this world famous battleship of the air. Through the hospitality of the commanding officer of the air station, the hangars will be visited Wednesday afternoon, January 27, when both the *Akron* and the *Los Angeles* are scheduled to be there. Special arrangements are being made with the railroad, which will furnish accommodations at a very reasonable figure.

Scenic Trip via George Washington and Bear Mountain Bridges

During the last convention, an inspection trip was made to the George Washington Bridge, then under construction. This engineering monument with its 3,500 ft. suspension span, the longest in the world, is now completed and in service forming an important traffic artery between New York and New Jersey. Further up the Hudson River at Bear Mountain is another famous span which forms an important connecting link between the highways on either side of the Hudson River. A ride over the highways in this vicinity provides a magnificent motor trip. De luxe buses will, on Wednesday afternoon, January 27, start from the Engineering Societies Building, cross the new George Washington Bridge, travel north up the Hudson River on the top of the Palisades to the Bear Mountain Bridge, cross the Bear Mountain Bridge and return to the starting point via scenic New York State highways.

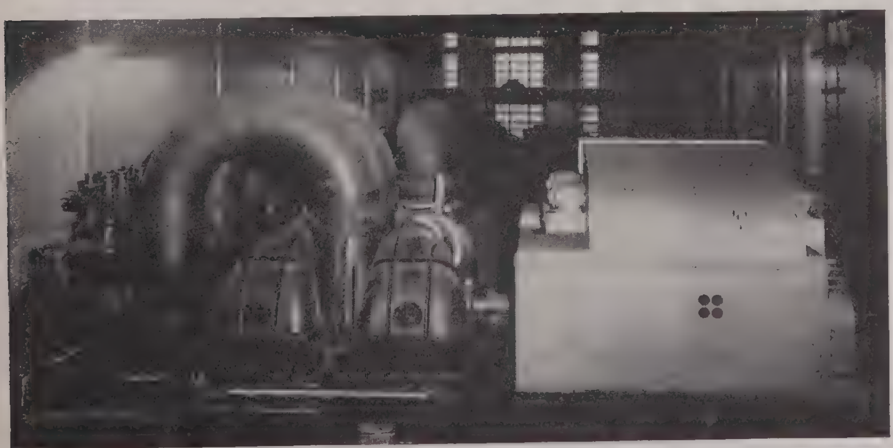
New Jersey Industrial Area

For those who would enjoy a bus trip through the industrial area of New Jersey, with brief stops at points of specificinte rest, a trip is in contemplation and will be described more fully in the convention literature.

Other Points of Interest

Opportunity will be afforded to those who wish to visit the installations of the neighboring utilities, railroad electrifications completed or in progress, or industrial and other enterprises which may command the interest of the members and their guests. Inspection privilege to visit the following places of interest has been accorded:

1. The Delaware, Lackawanna and Western Railroad Electrification
2. Roseland (N. J.) switching station of the Public Service Electric and Gas Company
3. 160,000-kw. tandem compound units of the Brooklyn Edison Company, and the company's research laboratory
4. East River generating station of New York Edison Company
5. New Eighth Avenue Subway substations
6. Vertical distribution in Empire State Building
7. Electrical Testing Laboratories
8. Lighting institute of the New York Electrical Society
9. New three-power locomotives of New York Central Railroad used for switching on West Side lines in New York City
10. Studio of Jenkins Television Corporation, where actual television broadcasting of dramatic sketches, and their reproduction as received on local receiver, may be witnessed
11. Lawrenceville (A.T.&T.) short wave radio station, and also control room at 24 Walker St., for ship-to-shore and transatlantic Service
12. Time service bureaus of New York Telephone Company, and Western Union Telegraph Company
13. Teletypewriter exchange service of American Telephone and Telegraph Company at 24 Walker St.
14. New York Museum of Science and Industry, where may be seen the new permanent exhibits relating to power, and electrical science and technology
15. New Lighting of the Statue of Liberty (See front cover)
16. Network protector exhibit and time control of street lighting circuits



200,000-kva. turbine-generator unit recently installed in the Brooklyn Edison Company's Hudson Avenue Station

Institute Directors Hold December Meeting

The regular meeting of the A.I.E.E. board of directors was held at Institute headquarters, New York, December 4, 1931.

Present were: *President*—C. E. Skinner, East Pittsburgh, Pa. *Past-president*—W. S. Lee, Charlotte, N. C. *Vice-presidents*—H. P. Charlesworth, New York, N. Y.; L. B. Chubbuck, Hamilton, Ont.; A. W. Copley, San Francisco, Calif.; W. B. Kouwenhoven, Baltimore, Md.; T. N. Lacy, Detroit, Mich.; I. E. Moultrop, Boston, Mass.; P. H. Patton, Omaha, Neb. *Directors*—L. W. Chubb, East Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; B. D. Hull, Dallas, Tex.; J. Allen Johnson, Buffalo, N. Y.; A. E. Knowlton, New York, N. Y.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y.; R. H. Tapscott, New

York, N. Y.; H. R. Woodrow, Brooklyn, N. Y. *National Treasurer*—W. I. Slichter. *National Secretary*—F. L. Hutchinson, New York, N. Y.

The minutes of the directors' meeting of October 23, 1931, were approved.

The following minute was adopted in memory of the late Dr. L. T. Robinson:

In the keen appreciation of the loss sustained by the field of electrical engineering and by the American Institute of Electrical Engineers through the death on November 3, 1931, of Dr. Lewis Taylor Robinson, the board of directors of the Institute adopts this minute and directs that a copy be sent to Dr. Robinson's family:

"In the passing of Lewis Taylor Robinson, there was removed from the profession of electrical engineering one of the men to whom that profession is most deeply indebted; who, as an Institute worker, gave generously of his time through service as manager and vice-president, and member for many years of the standards and many other committees; a man whose unselfish interest and devotion served as a steadying and guiding influence, and whose sound judgment and pleasing personality won for him throughout his long years of service the high respect of the many with whom he came in contact."

A report of a meeting of the board of examiners held November 24, 1931, was presented and approved. Upon the recommendation of the board of examiners the following actions were taken upon pending applications: 789 Students were enrolled; 45 Associates were elected; 7 applicants were elected to the grade of Member, and 15 were transferred to the grade of Member.

Approval by the finance committee of monthly bills amounting to $24,129.97 was ratified.

A resolution was adopted to the effect that the 1932 annual (business) meeting of the Institute will be held on Monday, June 20, at Cleveland, Ohio.

Appointments were made as follows: H. H. Barnes, Jr., as a member of the Edison Medal committee, succeeding Dr. L. T. Robinson (deceased); H. S. Osborne, successor to Doctor Robinson, as a representative of the Institute on the standards council of the American Standards Association; A. W. Berresford as an Institute representative on the board of trustees of the United Engineering Trustees, Inc., for the three-year term beginning January 1, 1932; and W. S. Barstow reappointed to the library board of the United Engineering Trustees, Inc., for the four-year term beginning January 1, 1932.

A communication from W. S. Barstow was presented, in which he advised of his intention to present to the Institute, a bronze bust of Thomas A. Edison (a replica of the marble bust presented last April to the Deutsches Museum, Munich, Germany) and the following resolution was adopted:

Resolved, That the board of directors of the American Institute of Electrical Engineers hereby expresses to Mr. William S. Barstow, a former director and vice-president of this Institute and now president of the Edison Pioneers, its high appreciation of his action in presenting to the Institute a bronze bust of Thomas A. Edison, and directs that this bust be placed upon exhibition in a prominent place at Institute headquarters.

The following new by-law was adopted, defining the scope of the committee mentioned therein:

The committee on economic status of the engineer shall consist of five members, and shall consider matters relating to the position, function, and responsibility of the engineer in the development of human welfare, and make reports and recommendations thereon to the board of directors. The committee shall cooperate with similar committees of other engineering societies, and shall also consider and report upon all matters referred to it by the board of directors, the president, and the national secretary.

In response to an invitation to be represented at the Seventh American Scientific Congress to be held in Mexico City, February 5-19, 1932, President Skinner was appointed as the Institute's delegate to this congress.

Upon invitation from the Kelvin Medal board of award (of England) to nominate a candidate for the award of the Kelvin Medal in 1932, the president was authorized to appoint a committee to report recommendations at the January meeting of the A.I.E.E. board.

The board accepted offers from Past-Presidents Ralph D. Mershon and William S. Lee each to donate a golf trophy (to replace the Mershon Cup which in June 1931 passed into the permanent possession of L. F. Deming of Philadelphia, and authorized the appointment of a committee to work out the details in connection with both trophies.

Consideration was given to a request from the Institute of Electrical Engineers of Japan for assistance in carrying out two projects under the Iwadare Foundation, as follows: (1) Sending Japanese electrical engineers to the United States each year to study, and (2) inviting each year distinguished electrical engineers from the United States to deliver several lectures in Japan. The appointment of a continuing committee to carry on this activity was authorized.

Approval was given to a proposal by The Engineering Foundation to establish a research procedure committee, consisting of one representative from each of the four national societies of civil, mining and metallurgical, mechanical, and electrical engineers, and two representatives of The Engineering Foundation. The president was authorized to appoint the Institute's representative on this committee. (President Skinner later designated L. W. Chubb, chairman of the Institute's committee on research.)

A report was received from G. L. Weller, the Institute's representative at the Fourth Pan-American Commercial Conference, held in Washington, October 5-13, 1931.

Other matters were discussed, reference to which may be found in this and future issues of Electrical Engineering.

A.I.E.E. Nominating Committee Announces Official Candidates for 1932

A COMPLETE official ticket of candidates for the Institute offices that will become vacant August 1, 1932, was selected by the national nominating committee which met at Institute headquarters, New York, December 3, 1931. This committee consists of fifteen members, one selected by the executive committee of each of the ten geographical districts, and the remaining five elected by the board of directors from its own membership.

The following members of the committee were present: C. T. Almquist, Norman, Okla.; F. J. Chesterman, Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; A. W. Copley, San Francisco, Calif.; Bancroft Gherardi, New York, N. Y.; B. D. Hull, Dallas, Tex.; W. B. Kouwenhoven, Baltimore, Md.; T. N. Lacy, Detroit, Mich.; P. H. Patton, Omaha, Neb.; C. E. Rogers, Seattle, Wash.; C. E. Stephens, New York, N. Y.; R. H. Tapscott, New York, N. Y. (alternate for A. M. MacCutcheon, of Cleveland, Ohio); R. G. Warner, New Haven, Conn.; and F. L. Hutchinson, New York, N. Y., secretary of the committee. Past-President Bancroft Gherardi was elected chairman of the committee.

The following is a list of the official candidates as selected by the committee:

For President

H. P. Charlesworth, vice-president, Bell Telephone Laboratories, New York, N. Y.

For Vice-Presidents

North Eastern District (No. 1): J. Allen Johnson, chief electrical engineer, Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y.

New York City District (No. 3): E. B. Meyer, vice-president, United Engineers & Constructors Inc., Newark, N. J.

Great Lakes District (No. 5): K. A. Auty, sales engineer, Commonwealth Edison Company, Chicago, Ill.

South West District (No. 7): G. A. Mills, chief engineer, Central & South West Utilities Company; vice-president, Pecos Valley Power & Light Company, Dallas, Tex.

North West District (No. 9): C. R. Higson, superintendent of distribution, Utah Power & Light Company, Salt Lake City, Utah.

For Directors

G. A. Kositzky, chief engineer, The Ohio Bell Telephone Company, Cleveland, Ohio.

A. H. Lovell, assistant dean and professor of electrical engineering, University of Michigan, Ann Arbor, Mich.

A. C. Stevens, in charge, educational sales, General Electric Company, Schenectady, N. Y.

For National Treasurer

W. I. Slichter, professor of electrical engineering, Columbia University, New York, N. Y.

The constitution and by-laws of the Institute provide that the nominations made by the national nominating committee shall be published in the January issue of Electrical Engineering. Provision is made for independent nominations as indicated in the following excerpts from the constitution and by-laws:

Constitution

Sec. 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the National Secretary when and as provided in the By-laws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

By-Laws

Sec. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 31 (Constitution), must be received by the secretary of the National Nominating Committee not later than February 15 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the National Nominating Committee in accordance with Article VI of the Constitution and sent by the National Secretary to all qualified voters during the first week in March of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) National Nominating Committee
By F. L. Hutchinson,
Secretary

Biographies of Nominees

That those not personally acquainted with the nominees may know something of them and their qualifications for the offices for which they have been recommended, brief biographical sketches of each are given herewith.

H. P. Charlesworth

Harry Prescott Charlesworth was born in Haverhill, Mass., April 7, 1882. After graduation by the Massachusetts Institute of Technology in 1905 with the degree of Bachelor of Science, Mr. Charlesworth entered the engineering department of the American Telephone and Telegraph Company, then located in Boston. His early assignments had to do with the development of telephone circuits and associated apparatus. Later he was active for several years in the development of toll operating methods and the general related engineering problems involved in extending and improving telephone service.

With the opening of the war he was specially assigned to handle problems wherein the Bell System could be of assistance to the government in the national emergency. In this capacity he was, throughout the war, active on communication facilities for army camps, naval bases, supply depots and particularly for the government departments at Washington, where he also assisted the telephone company on general equipment and traffic engineering matters.

Shortly after the close of the war he became for a short time equipment and transmission engineer of the American Telephone and Telegraph Company; in 1920 was appointed plant engineer of that company, in which position he was concerned with all phases of the engineering of the telephone plant and with relations with other wire using companies. In December 1928 he was elected vice-president of Bell Telephone Laboratories, Inc., where he now directs operations involving more than 5,000 people engaged in development, research and related activities pertaining to the communication art.

Mr. Charlesworth became a Member of the Institute in 1922 and a Fellow in 1928. Also, he was a manager (1924-1927), chairman of the meetings and papers committee (1927-1929), and chairman of the New York Section (1929). In 1930 he became vice-president (representing District No. 3) and member of the board of directors. He has served on many Institute committees, being at present a member of the executive, coordination, Institute policies, finance, legislation affecting the engineering profession, technical program, and the Edison and Lamme Medal committees. He also is a representative of the Institute on the board of United Engineering Trustees, Inc.; a member of the National Research Council's division of engineering and industrial research, vice-chairman of the A.S.A. electrical standards committee, and a member of several other scientific organizations.

J. Allen Johnson

Joseph Allen Johnson was born at Northboro, Mass., June 21, 1882, and received his early education in the schools of that town. He was graduated from the Worcester Polytechnic Institute with the degree of Bachelor of Science in electrical engineering in 1905.

From 1905 to 1912, he was employed in electrical engineering work by the Ontario Power Company of Niagara Falls, being appointed electrical engineer of that company in 1912. In 1917 this company was purchased by the Hydroelectric Power Commission of Ontario, of which Mr. Johnson became assistant engineer, but still retained his other position. In 1918 he was appointed electrical engineer of the Cliff Electrical Distributing Company and Hydraulic Power Company of Niagara Falls, N. Y. and with the consolidation of these companies and the old Niagara Falls Power Company to form The Niagara Falls Power Company in 1918, he became electrical engineer of the enlarged company. In 1929 he was appointed chief electrical engineer of the Buffalo Niagara & Eastern Power Corporation, which position he now holds.

Mr. Johnson has contributed several important technical papers on such subjects as excitation and voltage control, reactors in hydroelectric stations, fire protection in a-c. generators, retardation method of loss determination. In 1926 he was awarded the "best paper" prize for District No. 1, for his paper "The Retardation Method of Loss Determination as Applied to the Large Niagara Generators."

He joined the Institute as an Associate in 1907, and was transferred to the grade of Fellow in December 1927. He has served as a member of the electrochemistry and electrometallurgy, electrical machinery, and protective devices committees. He became a director of the Institute in 1928 and served as chairman of the membership committee for the two years 1929-31. He was the organizer and first chairman of the Niagara Frontier Section and served in that

A Scoreboard Visible Against Sunlight

THIS new electric scoreboard at Harvard's stadium, Cambridge, Mass., makes it possible for spectators to follow the ball, penalties, players, plays, and the score, with comparative ease. Moreover, the figures that flash across this new board are accurate and perfectly in time with the play itself, for the action of the board is controlled by a push-button station on the 50-yard line. The board, built by the General Electric Company, is 30 ft. long and 12 ft. high. The face is dull black and the ball and numeral indications are flashed to the spectators by groups of incandescent lamps so controlled that their brilliance varies with the amount of natural light over the field. Even with bright sunlight the numbers are clearly visible at 300 yd.

capacity from the date of its organization, February 10, 1925 to July 31, 1926.

He also is a member of the National Electric Light Association and the American Association for the Advancement of Science.

E. B. Meyer

Edward Barnard Meyer was born October 22, 1882, at Newark, New Jersey. He received his technical education at the Newark Technical School, from which he was graduated in 1901, and at Pratt Institute, Brooklyn, New York, whence he graduated from the electrical engineering course in 1903.

That same year, Mr. Meyer entered the employ of Public Service Corporation of New Jersey as an engineering assistant and remained continuously with that organization and its subsidiary companies until 1922, holding successively the positions of field engineer (1906) in charge of the underground conduit and cable system, assistant engineer (1909) supervising the preparation of special estimates and reports and of construction operations, and assistant chief engineer (1919). With the formation in 1922 of the Public Service Production Company he was appointed its chief engineer.

In 1929, Mr. Meyer was made a vice-president of Public Service Production Company, and in 1930, on the occasion of the merging of that company with United Engineers & Constructors Inc., he was appointed a vice-president of the latter corporation in the capacity of executive and engineering head of the Newark office.

Mr. Meyer became an Associate of the Institute in 1905, transferring in 1927 to the grade of Fellow. Active in Institute service, Mr. Meyer now is chairman of the following Institute committees: publication, award of Institute prizes, constitution and by-laws, Edison Medal, and the winter '32 convention; a member of the following committees: coordination of Institute activities, power generation, and representative for the Institute on the engineering societies monographs committee. Within recent years Mr. Meyer has been chairman of A.I.E.E. committees on meetings and papers (now technical program), transmission and distribution, finance, and executive committee of the New York Section; a member of the headquarters, Sections, membership, and several special and subcommittees. Also he was the Institute's representative on the U.S. national committee I.E.C.

Mr. Meyer's other technical activities have included active participation in N.E.L.A. and A.S.A. affairs, membership on the board of directors of the New York Electrical Society, Inc., membership in the Essex (County, N.J.) Electrical League, the U.S. Chamber of Commerce, the A.S.M.E., and the A.E.R.A. During the World War he served on important committees of the U.S. Army and Navy. His numerous contributions to the technical press have dealt chiefly with electric transmission and distribution problems and includes his book "Underground Transmission and Distribution."

K. A. Auty

Karl André Auty was born in Yorkshire, England, of English parents and is now in his fifties. His education was pursued in Wheelwright Grammar School, *H.M.S. Conway* a British Naval Training Ship, and in the military class of a Paris university.

Family circumstances having changed, he took the engineering course at Victoria University, Nottingham. He then (1899) entered the Brush Electrical Engineering Company (England) as an engineering pupil for a three-year practical and theoretical engineering course.

Subsequently Mr. Auty came into charge of the Brush company's Lancashire district office, making a specialty of electrifying textile mills and old fashioned traction systems. In 1909 he became the illuminating and power engineer and headed the sales promotional department of the British Columbia Electric Railway Company in Vancouver, Canada. During the period of his affiliation with that company he was an active participant in the organization of the Vancouver Section of the Institute, and in the newly formed company Section of the N.E.L.A. Also he became a member of the Illuminating Engineering Society. Late in 1915 he joined the Commonwealth Edison Company of Chicago, Ill. as power sales engineer in the contract department. During the World War, he also assisted the State Council of Defense of Illinois. In 1917, he won the Insull medal for his paper "Advertising our K.W.H.'s."

Mr. Auty became an Associate of the Institute in 1912, and in 1917 was transferred to the grade of Member. He has been secretary, (1924-5), vice-chairman (1925-6), and chairman (1926-7) of the Chicago Section, and a member of the 1929 and 1930 national nominating committees. As an active member of the Western Society of Engineers (Chicago) he has served as chairman of its electrical section (1926-7), member of its board of management, and member of its Washington Award commission (1927-9). He is an Associate of the Association of Iron and Steel Electrical Engineers. He assisted in the original foundation of the Midwest Power Engineering Conference, and for the past four years has served as its treasurer. He is an earnest advocate and ardent promoter of amateur sports, and is serving as president of several amateur athletic organizations.

Vertical Transportation

To CONNECT a bay front business district with a residential district 195 ft. above it, La Cerda Tower was placed in operation recently in Bahia, a coastal city in northern Brazil. The reinforced concrete tower is 240 ft. high and houses two large Otis express elevators reputed comparable with those used in the largest modern skyscrapers. On the day following its inauguration, more than 24,000 passengers were carried at 160 reis, a little less than two cents, per trip.

G. A. Mills

George Arthur Mills was born July 5, 1885, in Buchanan County, Iowa. Pursuit of his early education carried him through the East Waterloo, Iowa, high school (1903) to the Iowa State College at Ames, whence he graduated in 1909 with the degree of Bachelor of Science in electrical engineering.

Subsequent to his graduation from college, he served an apprenticeship course with the Allis-Chalmers Manufacturing Company at its works in Cincinnati, Ohio. From that activity he went to Philadelphia where he served the University of Pennsylvania as instructor in electrical engineering (1910-11).

Leaving his educational pursuits, he became in succession: electrical engineer for the Waterloo, Cedar Falls and Northern Railway Company at Waterloo, Iowa, (1911-17); electrical engineer for the Winnipeg Electric Railway Company, Winnipeg, Canada (1917-19); general superintendent for the Wisconsin division of the Northern State Power Company, at Eau Claire, Wis. (1919-24); vice-president and general manager of the Kewanee Public Service Company, Kewanee, Ill. (1924-26); chief engineer of the Central and South West Utilities Company, and vice-president of the Pecos Valley Power & Light Company, both of Dallas, Texas (1926-to date).

Mr. Mills became a Member of the Institute in 1918, and was a charter member and first chairman of the Dallas Section of the Institute, which was formed June 2, 1928.

C. R. Higson

Charles Roy Higson was born in Salt Lake City, Utah, August 29, 1893. After having completed his preliminary education in the grammar and high schools of Salt Lake City, he entered the University of Wisconsin, whence he graduated in 1907 with the degree of Bachelor of Science in engineering. In 1912 he was awarded the degree of Electrical Engineer.

During the period 1907-1908 Mr. Higson was with the General Electric Company, at Schenectady, in the test course. In 1909 he returned to the University of Wisconsin as instructor in electrical engineering, where he remained until 1912, when he entered the employ of the Utah Power and Light Company. He has been with that company continuously since then, holding the positions of engineering assistant (1913-18) assistant engineer (1918-25), and finally taking his present position of superintendent of distribution in 1925.

Mr. Higson became affiliated with the Institute in 1921, and has served as chairman of the Utah Section, and as chairman of the Pacific Coast convention committee (1926). He has taken a prominent part in engineering activities in Salt Lake City, and served in 1930 as president of the Engineering Council of Utah.

G. A. Kositzky

Gustav Adolph Kositzky was born April 20, 1879, at Yankton, South Dakota. His early education was obtained in the Yankton and Niobrara (Neb.) public schools. Subsequently he spent four years at the University of Nebraska and then two years at Cornell University, graduating in 1905 with the degree of Mechanical Engineer in electrical engineering. He then entered the employ of the New York and New Jersey Telephone Company at Brooklyn, N. Y., in construction and engineering work. In 1907 he was promoted to construction engineer and during the following two years engineered the rebuilding of the outside distributing plant in that city. Following this, he was loaned (1910) to the Pacific Telephone and Telegraph Company in charge of plant engineering work covering the larger cities along the Pacific coast.

In 1911 he was transferred to the South Western Bell Telephone Company. From that date up to 1919 he filled the positions of plant engineer, general plant superintendent, and general engineer. In this latter position he was in charge of valuation work in connection with several large rate cases in Missouri, Kansas, and Texas.

In 1919 Mr. Kositzky was appointed chief engineer of the Central Union Telephone Company operating in Illinois, Indiana, and Ohio with headquarters in Chicago. In 1921 he became the chief engineer of the Ohio Bell Telephone Company with headquarters at Cleveland, the position he now occupies. For the next several years he directed the engineering work in connection with the unification of telephone service throughout Ohio which came about through the merging of the Bell and independent companies. This presented the largest engineering problem in connection with the unification of telephone service in telephone history.

Mr. Kositzky became a Member of the Institute in 1922 and was transferred to the grade of Fellow in 1929. During this period he has been active in Institute matters and has served as a member of various committees both local and national, the latest as chairman of the communication committee during the years 1929 and 1930. At present he is chairman of the Cleveland Section. Also he has served the Cleveland Engineering Society as trustee, vice-president, and president (1928). He is a past-president of the Nebraska Club of Cleveland; is a member of the Cleveland Chamber of Commerce and of several social and athletic clubs.

A. H. Lovell

Alfred Henry Lovell was born in Hamilton, Ontario, Canada, July 13, 1884. His early education was obtained in the public schools of that city and in the Collegiate Institute at Niagara Falls. He received his degree of Bachelor of Science in electrical engineering from the University of Michigan in 1909 and his Master of Science degree from the same institution in 1914. He has had a varied experience in design and construction of power generation projects, having served on the engineering staffs of such organizations as the Ontario Power Company (1902-5), the Telluride Power Company (1906), the Rochester Railway & Light Company (1909-10), and the Gladwin Light & Power Company (1912). He has been on appraisal work with the Detroit Edison Company, the Mexia Power & Light Company, and others and on rehabilitation design of the Kansas City Railways plant. He was with Muralt & Company (1910-11), transmission line contractors for the Hydro-Electric Power Commission of Ontario.

During the war Professor Lovell served in the United States, England, and France as Colonel of Engineers with the 310th Engineers, (Michigan-Wisconsin) and later commanded the Third Engineer Training Regiment at Camp Humphreys, Va.

After serving since 1911 as an instructor he was appointed (1919) professor of electric power engineering at the University of Michigan, and in 1929 was appointed assistant dean of the College of Engineering, both of which positions he now holds. He is a member of Tau Beta Pi, Sigma Xi and Phi Kappa Phi. Professor Lovell has written for the Michigan Technic and is the author of a text "Generating Stations."

Professor Lovell became affiliated with the Institute in 1912 as an Associate, transferring to the grade of Member in 1913. He has served as secretary-treasurer, vice-chairman, and chairman of the Detroit-Ann Arbor Section, and now is a member of the Institute's committees on education and power generation. Also he is a member of the N.E.L.A. (Great Lakes Division) committees on overhead, and underground systems, and chairman of the committee on electrical engineering of the Society for the Promotion of Engineering Education.

A. C. Stevens

Alexander Chilson Stevens was born in Riverhead, Long Island, N. Y., October 9, 1883. After early schooling in Middletown, Conn. and White Plains, N. Y., he spent two years at Wesleyan University and three at Cornell. He graduated from the latter in 1907 with the degree of Mechanical Engineer in electrical engineering. After graduation he taught for several years, first at Wesleyan as instructor in descriptive geometry and physics, and later as instructor in electrical engineering at Cornell.

In 1917 Mr. Stevens joined the staff of the transformer engineering department of the General Electric Company in Pittsfield, Mass. In 1925 his interest in educational matters resulted in his being placed in charge of the sale of apparatus to educational institutions for his company, with headquarters in Schenectady, New York.

Mr. Stevens has been actively interested in A.I.E.E. matters since joining as an Associate in 1918. At Pittsfield he was, for some years before moving to Schenectady, a member of the executive committee of the local Section; successively chairman of several of the important standing committees, secretary, and vice-chairman-elect.

When the North Eastern District of the Institute was organized in 1922, he was chosen by Vice-President G. Faccioli to serve as district secretary, a position he has held ever since. The experience gained in planning the pioneer regional meeting at Worcester, Mass., and other early district activities was of great help to the Institute in formulating a definite policy with regard to other districts. In 1930 he accompanied President Harold B. Smith on an extended trip to Institute Sections in the Middle Eastern, Southern, and South Western Districts, going as far south as Mexico City.

Mr. Stevens is a member of the Society for the Promotion of Engineering Education, the Cornell Club of New York, Eta Kappa Nu, Delta Kappa Epsilon, and several Masonic fraternal organizations.

Engineers Condemn Bidding for Services

The practise of publicly soliciting bids from engineers and the responding to such invitations was condemned severely in the following resolution adopted some months ago by the American Society of Civil Engineers:

"Whereas, the Council of the American Institute of Consulting Engineers has been asked to give consideration to the practice, occasionally followed by certain public officials and some corporations, of soliciting from engineers bids for rendering engineering services; and

"Whereas, the Council is firmly of the opinion that, in the award of engagements for engineering services, the element of the price paid for such services is one of the least of several considerations which should receive weight in the determination of the award. Among those other considerations of the relative suitability of the several engineers under consideration for engagement are, their personal integrity and strength of character; their executive and administrative ability; the character, extent and variety of their professional experience; their general standing in the profession and before the public, etc., etc., and, lastly, the compensation expected; and

"Whereas, members of the engineering profession who respond to public invitations to submit bids for rendering engineering services, thereby:—

(a) Promulgate, encourage and dignify the above undesirable and objectionable practice;

(b) Lower their individual and professional reputation and standing; and

(c) Tend to bring indignity and discredit on an honorable profession, therefore,

"Resolved, that the Council of the American Institute of Consulting Engineers:

1. Strongly condemns the practice on the part of some public officials and corporations of publicly soliciting bids from engineers for the rendering of engineering professional services;

2. Expresses its strong disapproval on the part of engineers, and particularly on the part of Members of the American Institute of Consulting Engineers, of the practise of responding to such invitations to submit bids for their professional services;

3. Records its sincere belief that the above practices of extending and accepting invitations to submit bids for the rendering of engineering services are certainly not in keeping with the elements of professional character and dignity which should—and in large measure do—at present characterize and control the engineering profession, and which form most essential and important elements of the foundation on which the American Institute of Consulting Engineers is established."

Upon recommendation of the Institute's committee on code of principles of professional conduct, the board of directors of the Institute on December 4, 1931 adopted the following resolution:

Resolved, that the board of directors of the American Institute of Electrical Engineers hereby endorses in principle the resolution adopted by the American Institute of Consulting Engineers, June 4, 1930, condemning the practise of advertising for bids for engineering services, and

Resolved, further, that the board of directors urges members of the A.I.E.E. to oppose this practise, and to give their active support to suitable methods of emphasizing the importance of selecting engineers on the basis of their qualifications for the work under consideration.

Report Submitted on Illumination Congress

The report of the United States national committee of the International Commission on Illumination for the year ending November 1931 has been submitted by the president, E. C. Crittenden (A'19-M'22). Representatives of the Institute on this permanent committee are: A. E. Kennelly (A'88-F'13-Life Member and past-president); C. O. Mailloux (A'84-F'12-Life Member and past-president); and C. H. Sharp (A'02-F'12). Following are excerpts from this report:

Among the activities of the committee the outstanding events of the year have of course been the session of the International Commission held at Cambridge, England, September 13-19, 1931 and the International Illumination Congress which preceded the commission sessions. . . .

Technical sessions of the congress were held in Glasgow, Edinburgh, Buxton (in connection with Sheffield) and Birmingham, England.

It is impracticable to summarize the proceedings of the congress and the commission in any brief statement. In both cases many parallel sessions were held; 23 technical meetings were scheduled for the congress; 22 specialized and 3 general sessions were listed for the commission, and in addition there were numerous committee meetings and special conferences. . . . Reports (of these sessions) were presented in October 1931 by Mr. G. H. Stickney (A'04-F'24) and other delegates at the Pittsburgh meeting of the Illuminating Engineering Society, and it is hoped that a composite report based upon these may be published so as to be generally available. The full report of proceedings of the congress will be a bulky document; it is understood that copies will be supplied gratis to those who registered as members, and will be available for purchase by others.

At the sessions more than 100 papers by individual authors were presented in addition to the committee reports prepared under the 18 secretariat projects which constitute the major activities of the commission. . . . Contributions from the United States included 9 individual papers and 4 secretariat committee reports.

As to the value of the results of such an international gathering, it is difficult to form a definite opinion. Undoubtedly the sessions with the publicity which accompanied them helped to create in Great Britain a general appreciation of the value of good lighting and of the artistic values of special lighting. . . . In the more technical fields, properties of materials and methods of measurement, undoubtedly the sessions helped to promote uniformity of practise facilitating interchange of data. Definite progress was made also toward unification of practise in aviation lighting and the dimensions of lamp bases and sockets, the latter being a project of the International Electrotechnical Commission with the I.C.I. invited to collaborate. . . .

The next plenary session of the commission is scheduled for 1934; an invitation from the German national committee to meet in Berlin was accepted. . . . With regard to plans for the 1934 session, the American delegates urged that effort be made to concentrate upon a limited number of subjects and to have those subjects treated in a manner adequate and appropriate for an international meeting. . . .

For the use of those who may wish to consult the papers presented before the proceedings are issued, complete files have been placed in the office of the Illuminating Engineering Society in New York City.

Electricity in Modern Medicine Discussed Before New York Electrical Society

A MOST SUCCESSFUL meeting devoted to electricity in modern medicine was held by the New York Electrical Society, December 16, 1931, in the Engineering Auditorium, New York, N. Y. L.A. Coleman is president of this society and E.E. Dorting (A'13-M'22) is secretary. Dr. Howard Kelly, emeritus professor of gynecology at The Johns Hopkins University, Baltimore, Md., presided at the meeting and gave a short history of the subject.

The first speaker was Dr. G. Failla, physicist of the Memorial Hospital, New York, N. Y., who discussed "Physical Advances in the Treatment of Cancer by X-Rays." Doctor Failla described the method by which the cancer patient is exposed to x-ray radiation continuously 24 hr. a day for periods up to two weeks. The radiation is secured from a 900,000-volt Coolidge tube which for clinical work is operated at 700,000 volts with a current of 5 milliamperes. Under these conditions the tube can be operated continuously for several hours without trouble, and gives a radiation emission equivalent to that of 450 grams of radium costing more than $22,000,000. Various other X-ray tubes also are being used in the experiment. At present it is not possible to predict the outcome of this investigation. The important biological effects produced by these high voltage X-rays at any given point in the body are being evaluated, however, and it is hoped to determine conditions producing the best clinical effects.

Artificial Fever

The second speaker, Dr. C. F. Tenney of the Fifth Avenue Hospital, New York, N. Y., discussed the use of short wave radiation in raising the internal temperature of a patient. The equipment producing this fever consists essentially of a short wave radio machine having two plates between which the patient is placed. The resistance of the body to the short wave passing between the plates produces a rise in temperature particularly in the liver, kidney, spleen, heart, and muscles, so that without harm to the patient, the body temperature can be elevated from 98.6 to 104 and 105 deg. fahr., in from 60 to 80 minutes. The fever produced is followed by a sweat without initial chill, and is much more comfortable than other methods of producing fever. It is hoped that the method will be of lasting benefit in the treatment of rheumatism and diseases of circulation.

Doctor Tenney then described a portable equipment used for the production of localized heating, such as in the knee, ankle, or other small portions of the body, without producing a complete fever. The heater consists of a vacuum-tube oscillator and a full wave rectifier which supplies the high voltage for the oscillator. The high frequency oscillator consists of two pliotrons operating at a frequency of from 10,000,000 to 14,000,000 cycles, the output of 200 watts being concentrated between two plates. The rectifier, an oil-immersed transformer having a 4,500-volt secondary and feeding two half-wave hot-cathode mercury-vapor tubes, furnishes the 2,000-volt d-c. supply for the oscillator. A rheostat is connected in the primary circuit of the high voltage transformer to provide plate voltage regulation.

The condenser plates are of thin aluminum, 10 in. in diameter, and are covered with hard rubber plates 12 in. in diameter to prevent arcing should the patient or attendant come in contact with them. In the field of undamped waves between the plates there is a rapid alternation with a 2,000-volt drop in potential. The greatest heating consistent with tube output has been obtained from the use of a 30-meter wave, oscillating 10,000,000 times per sec. between plates.

Electrosurgery

A summary of the history of high frequency currents in medicine was given by Dr. G.E. Ward of The Johns Hopkins Hospital, Baltimore, Md. and instructor of surgery, University of Maryland. The physics of high frequency currents was discussed with special attention to the biophysical changes wrought in living tissue by the passage of so-called medical diathermy and electrosurgical high frequency currents. Diathermy currents are those which raise the temperature of a part or the whole of the body within physiological limits, while electrosurgical currents raise the local temperature well above that which is destructive to the cells. This destruction with related factors makes possible the use of such current in the eradication of tumors and other diseased tissues. Further attention was given by Doctor Ward to electro-cutting which has come into vogue in recent years for the removal of diseased areas.

The Electrocardiograph

The meeting was concluded with a discussion of the electrocardiograph by Dr. H. Williams, professor of physiology at Columbia University, New York, N. Y.

Doctor Williams told of the physical aspects of the electrocardiograph, and discussed the advantages of this equipment which is an important factor in the modern diagnosis of heart disease. The equipment makes use of the variation in electric current accompanying the contraction of the heart, and an instrument has been developed which is sufficiently sensitive and quick to follow the small and rapid changes in the movement of this organ.

A.S.M.E. Holds Annual Meeting

Economics shared honors with engineering as a subject of major interest at the fifty-second annual meeting of The American Society of Mechanical Engineers, held in New York, N. Y., November 30 to December 4, 1931. While the registration, approximately 2,000, fell somewhat behind that of last year, there was no falling off of interest and significance nor in the broad extent of the program. Statistics indicate that there were scheduled some 25 technical sessions, 72 committee meetings, with 80 technical papers and reports presented, in addition to 6 special lectures and numerous other activities of a social and professional nature.

Regarding the election of officers for 1931-32 announcement was made as follows: *President*, C.N. Lauer; *vice-presidents*, R.M. Gates, C.M. Allen, F.H. Dorner, and W.B. Gregory; *managers*, A.J. Dickie, E.W. O'Brien, and H.R. Westcott; *delegates to American Engineering Council*, C.N. Lauer, Paul Doty (M'12), R.E. Flanders, C.E. Ferris, L.P. Alford, J.H. Lawrence (M'28), R.C. Marshall, Jr. (M'19), A.A. Potter, W.H. Trask, Jr. (A'12), and E.C. Hutchinson.

The sessions included many papers of undoubted value to electrical engineers, and it is hoped that space in future issues of ELECTRICAL ENGINEERING will permit the inclusion of a major portion of this information.

Fellowship in Glass Founded.—Announcement has been made of the establishment by the Macbeth-Evans Company of a fellowship in illuminating glassware at the Mellon Institute of Industrial Research, Pittsburgh, Pa. It is stated that the scientific investigations to be conducted will be a continuation along original lines and entirely independent of the technological research being carried on in the Macbeth laboratories. Dr. R.R. McGregor, a specialist in physical chemistry, has been appointed to the incumbency of this fellowship.

Electricity to be Prominent in World's Fair

Extensive reservations for exhibit space in the electrical buildings of the 1933 World's Fair to be held in Chicago already have been contracted for by leading manufacturers of electrical equipment and supplies, producers of radios, and telephone and telegraph companies which provide the nation's principal communication facilities. The electrical group now is being erected on Northerly Island which adjoins the mainland at the fair site on Chicago's lake front; it is composed of three units: the electrical building, the communication building, and the radio building. (See ELECTRICAL ENGINEERING, V. 50, p. 762, Sept. 1931.)

Space on the first floor of the electrical building will be devoted to demonstrations of manufacturing processes; the second floor has been reserved for displays depicting the development of electrical engineering and electrical illumination. Connecting with the electrical building on the north is the communications building, all space in which already has been contracted for by leading telephone and telegraph companies; their exhibits will tell stories of the discovery, invention, and perfection of modern wire communication. At the extreme northern end of the group is the radio building. Exhibits already planned for this section will demonstrate how radio branched off from two-way communication and became the marvelous news and entertainment feature which it now is. In this building also it is expected to stage a broadcast sponsored by the two leading radio chains to demonstrate how programs of news, entertainment, and music are "put on the air."

In addition to the many attractive displays, stories of the epochal discoveries and inventions made in the field of electricity during the past hundred years will be told by men of vision and genius who are worthy successors to those who discovered and developed electric power. Thus in its entirety the electrical show is expected to be one of the most popular and spectacular features of the whole "Century of Progress" exposition.

Engineering Studies Open to Unemployed. Announcement is made by Dean J.W. Baker that classes in the engineering school of Columbia University have been opened to unemployed professional engineers. President Nicholas Murray Butler has sanctioned the measure after the proposal had been advanced by the professional engineers' committee on

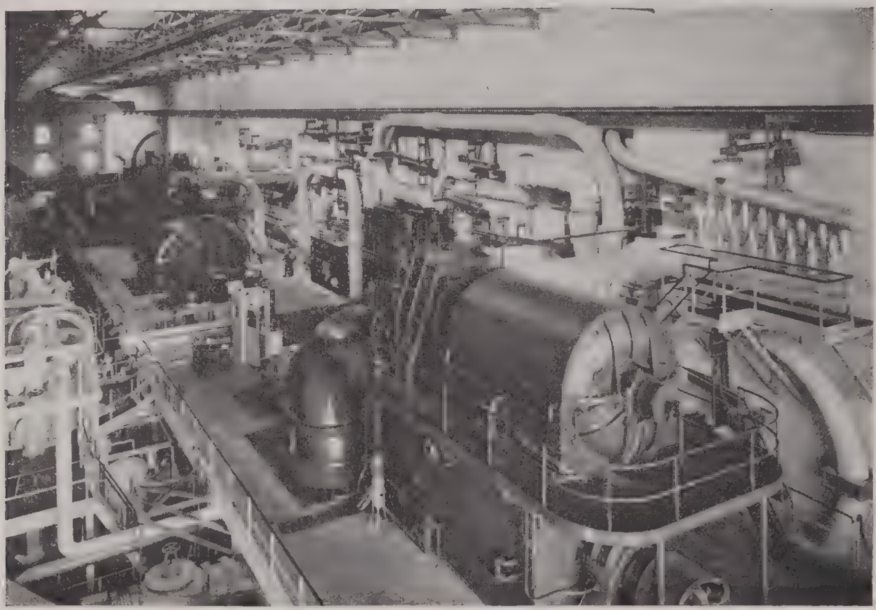
Hoover Dam Tunnels Near Completion

U.S. Bureau of Reclamation Photo

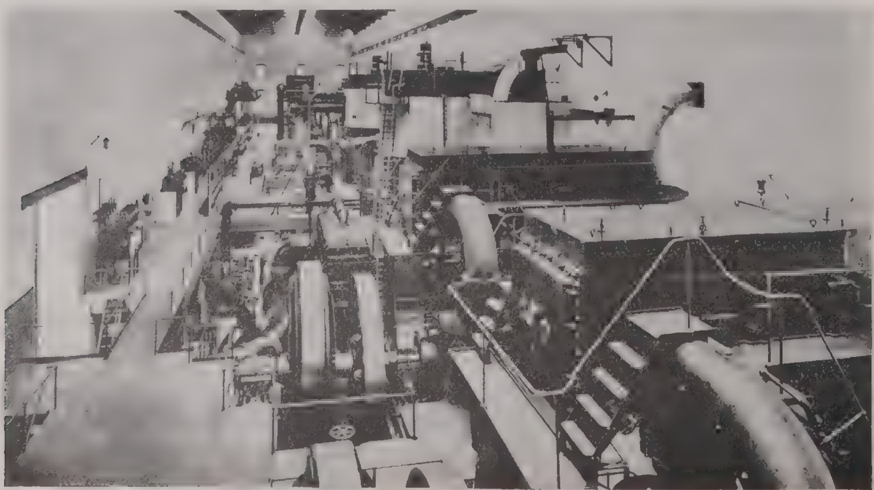
BEFORE excavation can be started on the foundation for Hoover Dam, four diversion tunnels each 4,000 ft. long must be completed. These tunnels (56 ft. diameter inside of rock, 3 ft. concrete lining) will divert the stream flow around the dam site. Downstream portals are shown above. The attack on these tunnels is from both upstream and downstream portals and from two additional faces in each tunnel opened by adits driven in from the canyon wall at about midpoint. More than 14,000 ft. of top heading has been completed, the two inner tunnels being holed through.

unemployment. Applicants must secure a certificate from the engineers' committee, showing that they are accredited members of the profession and are idle through no fault of their own. The number admitted will be limited by the size of the lecture halls only. By this means it is hoped to preserve morale during a period of enforced idleness, and to broaden the applicant's knowledge of engineering.

100,000 Kw. in Space Designed for 6,500



THE FIRST steam plant in the western states utilizing a boiler pressure of 1,400 lb. is station "A" of the Pacific Gas and Electric Company. The engine room of this plant, located in the center of the San Francisco industrial area, has had an interesting evolution. As constructed in 1901, it is 425 ft. long and 57 ft. wide; the original plant contained six vertical compound steam engines operating under 200-lb. pressure, and driving electric generators. By 1910 this equipment had been replaced by ten vertical reciprocating oil engines driving 1,500-kw. generators; by 1919, four 12,000-kw. turbo-generator units had replaced all but two of these engines, giving a plant capacity of 57,000 kw. This latter equipment, illustrated below, remained essentially intact until the most recent and perhaps the most striking change was made, when the two 50,000-kw. turbo-generator units shown above replaced two of the older turbo-generator units and two of the engine driven units. The same floor space required for 6,500 kw. in 1902 now contains equipment rated 100,000 kw. The steeple-compound units with the high-pressure turbine directly over the low-pressure one have not required even an increase in headroom.



American Institute of Physics Organized

Formal announcement has been made of the organization of the American Institute of Physics established by the American Physical Society, the Optical Society of America, the Acoustical Society of America, and the Society of Rheology. The new institute will serve the four societies mentioned, and through them, physics in general in matters of common interest, particularly in their relation to other societies and to the public. The board of management consists of Karl T. Compton, chairman, and G. B. Pegram, secretary. H. A. Barton is director, and J. T. Tate, advisor on publications.

The membership of the four societies establishing this institute includes a majority of the active physicists in the country, whether interested in pure or applied physics and whether filling university or industrial positions. This large group has felt first the need for unification of effort, and second for the existence of an agency which would perfect details of organization and co-operative publication of physics journals; also to assist the newspapers to disseminate accurate news of important developments and applications of physics. The value of these aims is obvious and it is also obvious that they do not conflict with the aims of any already constituted agency. It is indeed to be expected that those agencies of service to science already operating will find their scope and activities increased through the work of this institute.

"E.E." Offers Index and Binding Service

The annual index covering the contents of Electrical Engineering for the twelve issues of the calendar year 1931 will be available for distribution after January 15, 1932. It is to be published in a form convenient for those wishing to file it for reference or to include it in bound volumes of the 1931 monthly issues. A notice of this index appeared in the advertising section of Electrical Engineering for December 1931 and is repeated in this issue. An order form may be found on p. 992 of the December issue. The index will be printed in a quantity governed by the number of requests received prior to January 15, 1932.

The advertising pages for December 1931 included also the notice that binding service for the 1931 copies of Electrical

ENGINEERING now was available at cost. Upon shipment of the copies to the order department of the Institute, they will be bound neatly and durably, and returned prepaid. Full details are given in the advertising section of this issue and an order form appears on p. 70.

Consulting Engineers Denounce Free Engineering

The American Institute of Consulting Engineers, at the October meeting of its council, accepted a report of its committee on professional practise and ethics protesting against the furnishing of engineering plans and specifications by manufacturers and distributors of equipment and materials. The committee reported:

"The attention of the council of the American Institute of Consulting Engineers periodically has been called to the practise, on the part of large manufacturers and distributors of equipment and materials, of making investigations, engineering plans, and specifications for architects and owners, involving the use of equipment and materials which they sell, all apparently without charge or for a nominal charge.

"On at least two specific occasions the attention of the officials of several of the largest manufacturing concerns has been called to such practise without any apparent lasting results.

"The field of the professional engineer, engaged in private practise, constantly is being invaded by manufacturing concerns. both large and small, through the medium of offering to the prospective purchasers of their products of manufacture free consulting engineering service.

"It is clearly evident that such offering is made for the single purpose of selling their particular articles of manufacture, thus restricting the purchaser to products which may or may not be standard and of the best quality. It is equally evident that such practise not only is vicious, from the standpoint of the engineer engaged in private practise, but deprives the purchaser of the judgment of an impartial expert whose only interest is the interest of his client."

The committee therefore offered the following resolutions and recommended their adoption by the I.C.E.:

"RESOLVED, that the American Institute of Consulting Engineers denounces the practise of designing and planning of engineering work by those who have interests other than the efficiency and effectiveness of the installation, as *highly unethical*, and

BE IT FURTHER RESOLVED, that the Institute (I.C.E.) use such means as its council and/or officers deem best to eliminate such unethical purposes."

Copies of the report and notices of the action taken have been sent to the presidents of several corporations throughout the United States.

Letters to the Editor

Progress is the Way Out of Depression

To the Editor:

Mr. Berresford's article "Progress is the Way Out of Depression" in the December 1931 ELECTRICAL ENGINEERING is good promotion talk and has an excellent sales appeal in tending to make each human being think that he accomplishes more than the foremost leader. It may be exactly the kind of talk we should have at the present hour; I have been following his advice for the past year. Yet his primary thesis appears to be in conflict with many an article that I have read in the last ten or twenty years and also with my own observation.

The first part of the fourth paragraph, for example, seems to conflict with fundamental facts, although it may agree with superficial ones. Many of us think that the daily effort of the millions, when it is good, comes from the effort of the outstanding few and only from that source; we think this in spite of the essential failure of the church to provide adequate leadership, because there are successful leaders even among those who do not profess to be leaders. History indicates that without the thinking and the leadership of a few, man has tended to revert rather than to advance, which is largely why we are honoring Faraday this year.

"Do your bit as best you can" is good advice now and always will be, except for perverts, but all men are created equal only before the law. Without true leadership man has retrogressed in the past and will presumably continue to do so in the future. Hence in reading Mr. Berresford's article it will perhaps be well to keep in mind the possibility that, in trying to drive home his worthy point, he may have overstepped the bounds of fact. The end may at times justify the means, unless the means manufactures a boomerang.

Very truly yours,

H. H. KETCHAM (A'13-M'23 and Life Member) (Technical Editor, Forest Products Lab., Madison, Wis.)

Characteristics of Arc Welding Generators

To the Editor:

I acknowledge receipt of the paper by Mr. J. H. Blankenbuehler on "An Improved Arc Welding Generator." An article based upon this paper was published in ELECTRICAL ENGINEERING, August 1931, p. 666-8. The information contained therein is especially interesting to me as ten years ago I took a patent—No. 1,549,874—on the use of d-c. transformer in the welding and excitation self-circuits of any single-operator inherently—regulating arc welding generator.

The article explained many things to me that I did not understand before. However, my comments on his paper are that the statements regarding porosity being bettered by the welding machine and that freezing of the electrode is lessened by stopping the inrush of current are not agreed with by those people experienced in welding and are very misleading to others.

Freezing of the electrode is a phenomenon that is of no concern in welding because a good welder never freezes. Freezing or sticking is the earmark of an inexperienced or beginner welder. What is of some importance, however, is heating up the cold work as quickly as possible so the start of the weld is as well fused as the remainder. Welding, at present, is a compromise between too cold a start and too hot a finish. Porosity is caused by the latter—too hot a finish, and cold shots are caused by the former. It is very important to have the momentary rush at the starting as great as possible. Often a larger size sheet is used to effect this purpose. Sometimes tapered rods are used to offset this difference which obtains either in automatic or manual welding because all the heat that is in the arc, electrode or work, in the next instant is deposited in the work, which becomes hotter and hotter. Good welding consists of a compromise between how hot you can start without finishing so hot as to burn the metal, and judicious welding with invariably short lengths of electrodes have given the best results to date.

Furthermore, the curbing of the transient; that is, holding it below 200 per cent holds down the welding persistency. In other words, in chasing after this mechanical freezing of the electrode, the welding qualities are lessened. In other words, if you teach the machine to react quickly and then deliberately curb it, naturally both the properties of biting quick and holding back cannot be present under all conditions. You might be able to teach a dog to bite some people and not bite others but with a welding machine, I think it is quite impossible. So far, no one has discovered how to describe in technical terms this persistency of the arc but the difference between a machine that is curbed at 200 per cent and one that is allowed to react naturally with a time recovery of 2/10 of a second or less is the difference between Bobbie Jones or me or you.

Very truly yours,

C. J. HOLSLAG (M'19) (President, Electric Arc Cutting & Welding Co., 152 Jelliff Avenue, Newark, N. J.)

Has Man Benefited by Engineering Progress?

To the Editor:

The published introduction to the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" very definitely emphasizes the "deeper effects" of engineering achievement and its spiritual consequences. Mr. Mees' thought provoking article and letters of comment by Messrs. Dreher and Johnson are stimulating contributions to the announced topic. The apparent straying or lack of definiteness in some of the subsequent articles is disappointing. Too much responsibility is thrown upon the reader to deduce the author's viewpoint on the larger questions at issue.

Mr. Insull, conceding a disadvantage to humanity due to the congestion of industry in the past, predicts an improvement in the future because of the widespread distribution of power. In stating these well known facts about power supply and distribution, the author seems to imply that on the whole man has not benefited in a broad way in the era just opening, for the reasons stated. On the other hand, we may do the author an injustice. Perhaps he intends to imply all has been well and satisfactory as a result of engineering developments in the past

except the slight congestion of industry, and that little matter is well on the road to being corrected. A more definite commitment on the fundamental issues would have been welcome.

Mr. Grunsky emphasizes two principal points. First, a plea for the establishment of museums, art galleries, music conservatories, etc., as a stimulus for the spiritual uplift of the people. Second, a suggestion that these public improvements should be financed by new high rates of taxation, not, however, by the "prevailing unfair" system. As regards taxation, a great number of diverse theories have been proposed and many tried and discarded. Although engineers are (or should be) vitally interested in this topic, taxation has no more direct bearing on engineering progress and its effects than religion has. It is quite true, however, that not only taxation but religion and other institutions of our complex social order have an important effect on human welfare and happiness.

As regards the establishment of additional structures for spiritual uplift and public welfare, there are those who believe that not more edifices, but a more general acquaintance with the interiors of some already built (*e. g.*, places for worship) would better serve the purpose. However, this is beside the point. The responsibility of engineering developments is in no clear way indicated or even remotely suggested. The paper, indeed, is an excellent plea for the expansion of the fine arts as a basis for the spiritual uplift of the people. With this thesis the critic takes no exception, but manifestly the implied conclusion is, increase the number of artists, musicians, etc., but not the engineers. If the author had this conclusion in mind it would have been more satisfactory had he directly stated it. If he did not have this or a similar idea it is a little difficult to understand just how the paper fits into the symposium.

If the sponsors of these articles desire a general discussion of the fine arts, of religion, of psychology, of economics, of politics, etc., as well as of engineering progress, all of which have a direct bearing on happiness, there can be unlimited ramifications with but little coherence.

Yours very truly,

L. H. RITTENHOUSE (A'10)
(Professor of Engineering, Haverford College, Haverford, Pa.)

Nerve Injuries from Electric Shock

To the Editor:

The very interesting work done by W. B. Kouwenhoven and O. R. Langworthy as reported in the December 1931 issue of Electrical Engineering takes into account the effects of direct-current and low-frequency alternating-current.

The undersigned has observed that theories on "electric shock" are gradually shifting from the purely physiological viewpoint to a more biological and physical one. It seems to him that the primary causes of injury are of either electrolytic or thermic nature, and physiological effects are the result of heating or electrochemical decomposition of cell contents. A strong support for this thought lies in the fact that high-frequency currents injure the living body only through heating.

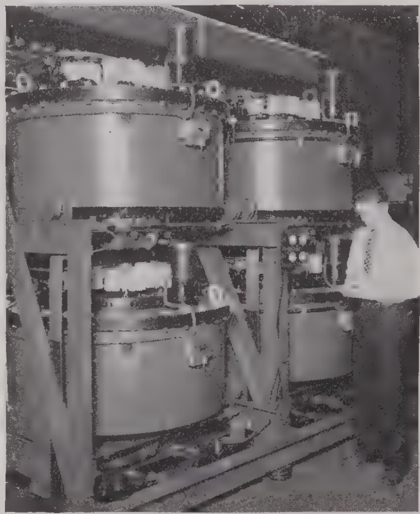
Lack of facilities so far prevented the writer from proving his theory experimentally. He believes that a continuation of the photomicrographic studies at The Johns Hopkins University with currents of higher frequencies will produce further interesting and valuable results.

Very truly yours,

KURT MAHNKE (A'26)
(401 Avenue D, Forest Hills, Pittsburgh, Pa.)

Mercury Arc Rectifiers of Sectional Construction

As the size of mercury arc rectifiers is increased, difficulties of design to secure satisfactory operation also increase greatly. Large units tend to be not only less reliable but actually less efficient than the smaller ones. To overcome these difficulties, there have been developed sectional rectifiers of the size which gives the best performance and so shaped that they may be placed together to form compact assemblies of any rating.



Westinghouse E. & M. Co. Photo

3,000-kw. rectifier made up of four 750-kw. sections

The 3,000-kw. rectifier unit illustrated consists of four interchangeable 750-kw. sections integrally mounted, fed from a single transformer, and easily withdrawn on rollers after the fashion of truck type switchgear. For this rating, the use of these sectional units results in a rectifier, each section of which is not only more reliable, but one in which a failure of one section does not involve complete shutdown of the entire group. Spare units may be provided easily. Piping and wiring are simplified, and both energy losses and space required are reduced by about one-third.

American Scientific Congress Postponed. Through the Pan American Union, word has been received from the Mexican Government announcing the postponement until November 1933 of the sessions of the Seventh American Scientific Congress, which was to have been held in Mexico City February 5-19, 1932. It was found that present world conditions make it impossible for many nations to send special representatives.

Test Code for Transformers now Available

Pursuant to notice which appeared in the October issue of Electrical Engineering (p. 844) giving publicity to effort on the part of the Institute's standards committee to develop test codes for electrical machinery and apparatus, this committee now has formulated a preliminary report on the proposed "Test Code for Transformers," pamphlet copies of which may be obtained without charge from A.I.E.E. headquarters, 33 West 39th Street, New York, N. Y.

American Engineering Council

N.J. Engineers Promote Public Works for Relief

A statewide plan of municipal improvement is sponsored by a New Jersey employment committee of the A.E.C. which has just been organized with Lynne J. Bevan of Montclair as chairman. The aid of the 2,800 licensed engineers and land surveyors in the state will be enlisted in shaping public works programs in every community.

These programs will be adjusted to a state plan, the legislature having provided that the state, to the limit of allotments, may meet dollar for dollar the money paid by local political units for labor or personal services. Tasks ranging from city planning studies to road and street repairs and the remodeling of public and semi-public buildings are suggested; elimination of grade crossings, widening and beautifying of streets, plans and estimates for future highways and parks are other objectives.

The members of the committee include: Governor Morgan F. Larson; Harvey N. Davis, president of Stevens Institute of Technology, Jersey City; L. P. Alford, Montclair, vice-president of The Ronald Press (N. Y.); Lincoln Bush, East Orange, past-president of the American Society of Civil Engineers; Dean P. H. Daggett (A'08) Rutgers University, New Brunswick; Charles A. Mead, chief engineer of the division of bridges and grade crossings of the New Jersey Public Utilities Commission; E. B. Meyer (F'27), Newark, vice-president, United Engineers and Constructors, Inc.

The committee also will work with the professional engineers unemployment relief committee organized in New York by the four Founder engineering societies

to aid idle engineers throughout the whole New York metropolitan area. A New Jersey section of the latter committee has been formed with Louis A. Janny of the American Institute of Mining and Metallurgical Engineers as chairman.

The engineers, according to Chairman Bevan, purpose to stimulate legitimate construction work, and to avoid unsound projects. "The immediate objective upon which your action is requested," he said in an appeal to the engineers and surveyors, "is the bringing to light of sufficient necessary public project work in your vicinity, and the incorporation thereof in the official plan of your community which must be filed with the state director of emergency relief by December 1, 1931."

Personal

Edwin W. Rice, Jr. Awarded Edison Medal

Dr. Edwin Wilbur Rice, Jr., has been awarded the A.I.E.E. Edison Medal for 1931 "for his contributions to the development of electrical systems and apparatus and his encouragement of scientific research in industry." The Edison Medal was founded by associates and friends of Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee consisting of 24 Institute members.

Doctor Rice is one of the pioneers of electrical development in the United States and has played a conspicuous part, in association with the late Charles A. Coffin, in the building of the present General Electric Company. As a schoolboy in Philadelphia he came in contact in 1876 with Prof. Elihu Thomson, then a young teacher in the Boys' Central High School. When in 1880 the professor gave up teaching to go into electrical manufacturing as scientist and inventor, young Rice gladly accepted an opportunity to become his assistant. He went with Thomson to New Britain, Conn., in the old American Electric Company, and in 1883 went with the professor to Lynn, Mass., upon the organization of the Thomson-Houston Electric Company. At the age of 22 he was made plant superintendent and had this full responsibility until the consolidation of the Thomson-Houston Electric Company and the Edison General Electric Company in 1892, under the name of General Electric Company.

In the new company Doctor Rice first was made technical director, then vice-president in charge of manufacturing and engineering. Eventually he became senior vice-president and, in 1913, he succeeded Mr. Coffin as president of the company. In 1922, after nine years' service in that office, he was succeeded by Gerard Swope. Doctor Rice at that time was made honorary chairman of the board, which position he still holds. He has contributed much through organization methods, improved factory routine, technical development, and engineering and scientific inventions to the prominence attained by the General Electric Company. His degrees are: Honorary A.M., Harvard (1903); Sc.D., Union University (1906); Doctor of Engineering, Rensselaer Polytechnic (1917); Sc.D., University of Pennsylvania (1924).

E. W. RICE, Jr.

He is a past-president and Fellow of the Institute, and a Chevalier Legion d'Honoeur of France. In 1917 he was decorated by the emperor of Japan with the Third Order of the Rising Sun with Cordon. He invented the present fundamental form of high-voltage oil switch and the cellular system of separating buses and circuits; as well as the application of synchronous converters to the building of unified a-c. and d-c. distribution systems. He was responsible for the adoption by his company of the Curtis steam turbine, and for the establishment of the company's research laboratory. He has endorsed and promoted many modern forms of industrial organization and of methods of advancing employees' welfare.

As a recipient of the Edison Medal, Doctor Rice shares the honor with: Elihu Thomson, Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell, Nikola Tesla, John J. Carty, Benjamin G. Lamme, W. L. R. Emmet, Michael I. Pupin, Cummings C. Chesney, Robert A. Millikan, John W. Lieb, John White Howell, Harris J. Ryan, William D. Coolidge, Frank B. Jewett, Charles F. Scott, and Frank Conrad.

A. B. Campbell (A'19) after thirteen years of service with the General Electric Company's Fort Wayne (Ind.) plant, where he was intimately connected with various developments of demand meters, thermal relays, timing devices, and allied equipment for the meter and fractional horsepower motor departments, is now chief engineer for the Seth Thomas Clock Company, Thomaston, Conn. While in Fort Wayne, Mr. Campbell served the A.I.E.E. as both secretary and chairman of its Fort Wayne Section.

Bancroft Gherardi (F'12) was reelected president (1932) of the American Standards Association at its annual meeting held in New York City December 9, 1931. Mr. Gherardi is vice-president and chief engineer of the American Telephone & Telegraph Company (N. Y.); active in Institute affairs, he has served prominently as president (1927-8) vice-president (1908-10) and manager (1905-8 and 1914-17).

G. N. Brown (M'21) who formerly was associated with the New York office of the Ohio Brass Company, sales department, now has joined the commercial staff at N.E.L.A. headquarters, as manager of its electric refrigeration bureau. Mr. Brown's service with the Ohio Brass Company extended over a period of four years as district manager, first of the Philadelphia office, and then of the New York office.

J. C. Parker (F'12) was relected December 9, 1931, at the annual meeting of the American Standards Association to serve (1932) as vice-chairman of the Standards Council. Mr. Parker is vice-president in charge of engineering for the Brooklyn (N. Y.) Edison Company; he has served the Institute in several capacities including that of vice-president (1921-2).

J. A. Foley (A'31) from 1923 to 1930 in the engineering design, application, and sales departments of the General Electric Company in both Cleveland and Toledo, Ohio, in the latter location serving also as engineering consultant over a period of approximately two years, recently became an electrical engineer of the Worthington Pump and Machinery Corporation in Chicago, Illinois.

P. J. Wilson (M'12) formerly sales manager of the Narragansett Electric Company, Providence, R. I., recently resigned to become vice-president and treasurer of the New England branch of Kaslin & Company, Inc., with main offices in Syracuse, N. Y. Mr. Wilson's headquarters, however, will be in Providence.

K. W. Johansson (M'28) formerly serving the Westinghouse Electric and Manufacturing Company as an electrical

engineer at the East Pittsburgh plant, now is special representative covering oil fields and other industries in Venezuela, Columbia and other South American countries for the Westinghouse Electric International Company.

R. S. Eininger, Jr. (A'29) who has been serving the General Electric Company, Erie, Pa., as cost engineer now has joined the company's force at Pittsfield, Mass., in the manufacturing general department. Mr. Eininger was student secretary of the Drexel Branch during the year 1926-27.

Clyde Treon (A'28) for some time past distribution superintendent of the Pernambuco Tramways & Power Company, Pernambuco, Brazil, South America, has returned to the United States and is serving now in like capacity with the West Penn Power Company, Pittsburgh, Pa.

Fraser Jeffrey (F'24) electrical engineer with the Allis-Chalmers Manufacturing Company, West Allis, Wis., recently was elected vice-president of the Engineers' Society of Milwaukee, of which he has been a member since 1907 when he started his career in the electrical industry.

J. C. Van Horn (M'28) has been made a vice-president of the R.C.A. Institutes, Inc., Philadelphia, Pa., and will have charge of resident schools at Philadelphia, New York, Chicago, and Boston. Mr. Van Horn has been serving the R.C.A. Institutes as general superintendent.

Winthrop Allen (A'30) has changed his work as assistant electrical engineer of E. I. duPont de Nemours Company, Wilmington, Del., to associate himself with the Prudential Insurance Company, Newark, New Jersey, as electrical engineer of home office buildings.

Paul S. Clapp (A'18) until recently managing director of the National Electric Light Association, New York, N. Y., resigned from that office to become vice-president of the Columbia Gas and Electric Corporation, with offices at its headquarters in New York City.

E. G. Waters (A'90) who has completed a record of more than 42 years of continuous service with the General Electric Company, and for the past 25 years has been secretary of its sales committee at Schenectady, N. Y., now at his own request has been retired.

E. J. Verrier (A'28) recently serving as electrical engineer of the Engineering Equipment Company, Montreal, Can., now has been made power plant superintendent for the Anglo Newfoundland Development Company, Grand Falls, Newfoundland.

S. R. Barrett (A'28) who in the past has been associated with the Hemenway Electric Corporation, Springfield, Vermont, now is station operator for the Turners Falls Power and Electric Company, Cobble Mountain Station, Westfield, Mass.

C. H. Willis (M'28) who since 1926 has been assistant professor of electrical engineering, Princeton University, Princeton, N. J., now has become associate professor in the electrical engineering department of the university.

B. S. Anderson (A'30) manager of the Japan branch of the English Electric Company, Ltd., at Tokyo, now has been transferred to Shanghai, China, where his address will be in care of Jardine Engineering Corporation, Ltd.

J. T. Serduke (A'30) until recently a research engineer at the General Electric Company's laboratory, Schenectady, N. Y., has joined the department of physics, Massachusetts Institute of Technology, Cambridge, Mass.

T. R. Cook (M'16) who has been engineer of Coverdale and Colpitts, consulting engineers, New York City, recently was made service manager of the Baldwin Locomotive Works' Paschall station, Philadelphia, Pa.

Emerick Toth (A'29) formerly laboratory assistant, Kolster Radio Corporation, Newark, N. J. recently became receiver engineer of high frequency circuits for Wired Radio, Incorporated, Ampere, N. J.

Herbert Southworth (A'22) formerly merchandise manager for the Fall River Electric Lighting Company, Fall River, Mass., now is assistant manager of the North Adams Gas Light Company, North Adams, Mass.

G. G. Post (A'11) vice-president and chief electrical engineer of the Milwaukee Electric Railway & Light Company, Milwaukee, Wis., recently was elected a director of the Engineers' Society of Milwaukee.

H. A. Luedeke (A'29) has joined the National Broadcasting Company, New York, N. Y., as monitoring engineer. His previous work was with the Western Electric Company, at Kearny, N. J., as design engineer.

M. B. Karelitz (A'27) who has been an engineer at the Westinghouse Electric and Manufacturing Company's main plant, East Pittsburgh, Pa., now has been transferred to the company's East Springfield works.

John Egli (M'26) who has been manager of service and erection for the American Brown Bovari Electric Corporation, now is with the Allis Chalmers Manufacturing Company, Milwaukee, Wis.

M. G. Lord (A'22) who since 1907 has been in the ranks of companies affiliated with the Southern Colorado Power Company, Pueblo, Colo., now is vice-president in charge of operation for that company.

O. B. Parker (A'29) for the past four and a half years assistant chief engineer of the Pacent Electric Company, Inc., New York, N. Y., has been promoted to the position of chief engineer.

J. W. West (M'28) who has been manager of production for the R.C.A-Victor Corporation at Camden, N. J. now has joined Frozen Confections, Incorporated, Maplewood, N. J.

H. P. Currin (M'30) electrical engineer of the Eugene water board, Eugene, Ore., now has been appointed electrical engineer of the State board of engineering examiners of Oregon.

H. A. Faesi (A'27) serving in the past as an electrical engineer, for Allied Engineers, Incorporated, Atlanta, Ga., now has joined the Georgia Power Company in that city.

Obituary

Howard Rankin Sargent (A'96-M'12 and Member for Life) engineer of the merchandise department of the General Electric Company, Bridgeport, Conn., died suddenly at his home in that city, December 8, 1931. The relapse followed an operation for appendicitis. Mr. Sargent was sixty years of age and a native of Newton, Mass. He was graduated from Massachusetts Institute of Technology in 1893, and promptly thereafter entered the employ of the old Thomson-Houston Company at Lynn, Mass. There he remained, with the exception of an interval during which he was working at Marlboro, Mass., until in 1894 many of the Lynn engineers were transferred to Schenectady. When the merchandise department of the company was organized in 1922, Mr. Sargent was transferred to Bridgeport as manager of the wiring supplies engineering division. In 1926 he was made engineer of the merchandise department. In the course of his professional career, Mr. Sargent has been credited with many important elec-

trical inventions. He also was active in the National Electric Light Association and the National Electric Manufacturers Association.

Joseph Walter Miles (A'02) for many years in charge of foreign engineering for the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and recently appointed consulting engineer to the foreign and development information bureau, died suddenly November 28, 1931. Mr. Miles had been a member of the Westinghouse organization for thirty-seven years, and lacked only six years' membership to qualify as a Member for Life of the Institute. He was still a resident of Irwin, Pa., where he was born July 20, 1870. As a student of archeology had made several investigations of that vicinity and was the author of a book "The Sewickley Indian," describing an ancient tribe of Pennsylvania. He studied at the University of Pennsylvania and Cornell University, and from the latter obtained his M.E. degree in 1893. For two years he was with the Westmoreland Coal Company, following which he commenced his long service with Westinghouse.

William Isaac Donshea (A'03-M'13) retired, died December 21, 1931. Mr. Donshea was born in New York City August 2, 1858. After completing his education, Mr. Donshea's first position was with the New York Telephone Company as operator and inspector in 1879-80, which position he left to become electrician and general superintendent, installing telephone exchanges in South America for the Telephone Company of Brazil from 1880 to 1887. During the years 1882-5 he also assisted in installing an Edison exhibition electric plant at the National Industrial Exhibition in Rio de Janeiro; a Thomson-Houston exhibition electric plant in Rio de Janeiro, and an Edison-Swan electric light plant in a Brazilian industrial mill. Following this and up to 1929 Mr. Donshea was an operating electrician and a district operating superintendent with the New York Edison Company. In 1929 he retired from active service after 50 years in the electrical industry.

Local Meetings

Future Section Meetings

Akron

Jan. 12—X-Ray Inspection of Welds, by Ancel St. John, pres., St. John X-Ray Service Corp. Movies: "Story of Steel." Meeting to be held in the auditorium of the Ohio Edison Co.

Feb. 9—At 4:00 p.m. inspection trip through the Ohio Edison Company's East Akron substation. At 7:45 p.m. movies: "Through Oil Lands." At 8:15 p.m. James H. Foote, Allied Engineers, Inc., will speak on Load Shifting Transformers at Salt Springs. Meeting to be held in the auditorium of the Ohio Edison Co.

Chicago

Jan. 7—Control of Noise and Vibration in Station Design, by P. E. Stevens, Byllesby Engg. and Mgmt. Corp.

Feb. 10—Modern Underground Cable Practise, by Herman Halperin, Commonwealth Edison Co.

Cleveland

Jan. 21—Some Institute Problems, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co.

Feb. 18—Lightning—Recent Investigations and Findings, by K. B. McEachron, Genl. Elect. Co., Schenectady, N. Y.

Dallas

Jan. 18—General Developments of 1931, covered by engineering students of the Southern Methodist Univ. Student Branch.

Detroit-Ann Arbor

Jan. 19—Ladies' night.

Feb. 16—Fundamental Physical and Psychological Aspects of Television, by J. O. Perrine, Am. Tel. & Tel. Co. Demonstrations. Meeting to be held in the auditorium of the Michigan Bell Tel. Co.

Lehigh Valley

Jan. 15—Primary Network Distribution Systems, by D. K. Blake, Gen. Elec. Co. Meeting to be held at Packard Lab. Lehigh Univ., Bethlehem, Pa.

Feb. 12—Airplane and Ship-to-Shore Communication. Speaker to be announced. Meeting to be held in Scranton.

Louisville

Jan. 22—Practical Application of Light Sensitive Cells, by J. V. Briesky, Westinghouse Elec. & Mfg. Co.

Feb. 19—Lightning—Recent Investigations and Findings, by F. W. Peek, Jr., Genl. Elect. Co., Schenectady, N. Y.

Lynn

Jan. 6—Ladies' night.

Jan. 16—Inspection trip to Loose Wiles Biscuit Co.

Jan. 20—Local convention. Subject: Centrifugal Air Compression.

Pittsburgh

Jan. 12—Dinner meeting. Speaker: Dr. C.E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Joint meeting with student Branches.

Feb. 9—New Developments in Mercury Arc Rectifiers. Speaker from the Westinghouse Elec. & Mfg. Co.

Pittsfield

Jan. 19—Personal Turn of Foreign Power Systems, by Philip Sporn.

Feb. 2—Jungle Gods, by Capt. Carl Von Hoffman.

Feb. 16—Man-Made Islands to Speed Ocean Flying, by E. R. Armstrong.

Seattle

Jan. 19—Presentation of papers submitted for annual prize competition. Titles and speakers to be announced.

Feb. — —Communication meeting. Speaker to be provided by the Am. Tel. & Tel. Co. Joint meeting with Inst. of Radio Engrs.

Vancouver

Jan. 4—Subject and speaker to be announced.

Feb. 1—Metering, by F. J. Bartholomew, Elec. Pwr. Equipment Co., and L. B. Stacey. Packard Elec. Co.

Past Section Meetings

Akron

Oil Purification, by R. P. Dunmire, vice-pres., The Buckeye Lab., Inc. Dinner meeting. Nov. 10. Att. 52.

Atlanta

Spain and America, by M. L. Brittain, pres., Georgia School of Tech. Oct. 12. Att. 80.

Technical Achievements vs. Social Responsibility, by J. E. Thomas, Commonwealth & Southern Corp. Joint meeting with A.S.M.E. Nov. 23. Att. 169.

Baltimore

Research, Theory, and Practise, by E. L. Manning, Genl. Elec. Co. Demonstrations. Dinner meeting. Nov. 20. Att. 57.

Boston

Adventures in Science, by L. A. Hawkins and E. L. Manning, Genl. Elec. Co. Demonstrations. Joint meeting with engineering societies of Boston. Nov. 12. Att. 3,600.

Chicago

Adventures in Science, by L. A. Hawkins, Genl. Elec. Co. Joint meeting with the Western Soc. of Engrs. Nov. 23. Att. 392.

Cincinnati

New Conceptions in Physics, by Dr. R. C. Gowdy, dean of the college of engineering and commerce, Univ. of Cincinnati. Illustrated. Considerable discussion. Dinner meeting. Oct. 29. Att. 65.

Power System Stability, by Robert Treat, Genl. Elec. Co. Motion pictures showed short circuit tests on the system of the New England Pwr. Co. Nov. 12. Att. 60.

Cleveland

Licensing of Engineers, by Dr. W. B. Kouwenhoven of The Johns Hopkins Univ., (Baltimore) vice-pres. A.I.E.E.; Engineering in Russia, by A. G. McKee, pres., Arthur G. McKee & Co. November 19. Att. 281.

Connecticut

Modern and Practical Uses of Illumination, by A. J. Sweet, Westinghouse Lamp Co. Dinner meeting. Nov. 19. Att. 50.

Dallas

International Telephone Service, by H.S. Osborne, Am. Tel. & Tel. Co., N.Y Illustrated. Nov. 23. Att. 86.

Detroit-Ann Arbor

Power System Stability, by Robert Treat, Genl. Elec. Co. Dinner meeting. Nov. 10. Att. 125.

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Dec. 1. Att. 175.

Erie

Effects of Electric Shock, by Dr. W. B. Kouwenhoven, of The Johns Hopkins Univ., (Baltimore) vice-pres. A.I.E.E.; European Travelogue, by J. J. Burgoyne, New York Central Rr. Co. Annual banquet and ladies' night at which James Burke of Burke Elec. Co., acted as toastmaster. Nov. 20. Att. 86.

Fort Wayne

The Hysteresis Motor, by S.L. Moore, Genl. Elec. Co.; A New Technique in Cathode Ray Oscillography, by C. M. Summers, Genl. Elec. Co. K. E. Ross, Genl. Elec. Co. demonstrated the cathode ray oscillograph. Nov. 19. Att. 80.

Houston

International Telephone Communication, by H. S. Osborne, Am. Tel. & Tel. Co., N. Y. Nov. 27. Att. 68.

Iowa

Coordination Between Electric Supply Lines and Communication Lines, by H. H. Carl, Northwestern Bell Tel. Co. Demonstrations. Oct. 29. Att. 39.

Lehigh Valley

Recent Developments in Surge-Proof Transformers, by H.V.Putman, Westinghouse Elec. & Mfg. Co. Illustrated. L. A. Phillips, Penn. Pr. & Lt. Co., and O. A. Griesemer, Lehigh Portland Cement Co., received prizes for obtaining the largest numbers of national and local members during the past season. Oct. 16. Att. 99.

Los Angeles

The Metropolitan Aqueduct, by F.E.Weymouth; Electrical Problems on the Aqueduct, by J. M. Gaylord. Both speakers are connected with the Metropolitan Water District. Dinner meeting. Nov. 10. Att. 205.

Louisville

The Mercury Arc Rectifier in Modern D-C. Railway Service, by E.M. Bill, Genl. Elec. Co. Also inspection trip to see the 1,000-kw. 600-volt automatic rectifier installed at the Highland substation of the Louisville Gas & Elec. Co. Nov. 20. Att. 145.

Lynn

The Call of the North, by A. H. Merritt. Illustrated. Nov. 4. Att. 1,200.

Inspection trips made Nov. 7 and 14 to the new building and plant of the Boston Herald-Traveler. Total att. 250.

Low Voltage A-C. Network, by O. L. Riggs, Lynn Gas & Elec. Co.; Low Voltage Metering Methods, by H. F. Crotty, Genl. Elec. Co.; Astronomical Time Switches, by F. W. Hottenroth, Genl. Elec. Co. Slides and working models used to demonstrate important features. Nov. 17. Att. 240.

Memphis

N.H.Brown, dean of the college of engineering, Arkansas A. & M. College, related instances from his experiences during the infancy of the electrical industry. Nov. 10. Att. 30.

Milwaukee

Modern Methods in Aerial Photographic Mapping, by C. H. Birdseye, pres., Aerotopograph Corp. of America. Joint meeting with the Engineers' Soc. of Milwaukee. Sept. 16. Att. 200.

Some Factors Affecting Noise in the Telephone Circuits Arising in Induction Exposures, by H. R. Huntley, Am. Tel. & Tel. Co., N. Y. Illustrated by lantern slides and a complete miniature hook-up of telephone and transmission lines. Joint meeting with Engineers' Soc. of Milwaukee. Oct. 21. Att. 200.

Continuous, Quick-Freeze Process for the Manufacture of Ice, by Wm. H. Taylor, read by Harry Sloan. Motion pictures and slides. Joint meeting with Engineers' Soc. of Milwaukee. Nov. 18. Att. 175.

Minnesota

Modern Trends in Illumination, by O. P. Cleaver, Westinghouse Lamp Co. Dinner meeting. Nov. 19. Att. 55.

Niagara-Frontier

Keeping Up with Buffalo's Growth—the Changing Requirements for Telephone Service in a Growing City, by B. K. Boyce, N. Y. Tel. Co. Informal dinner at Hotel Statler preceded the meeting. Nov. 20. Att. 115.

North Carolina

Incandescent Lamp Efficiency Life Tests, by D. J. Thurston, student, Univ. of No. Carolina; Practical Relay Applications to Transmission Systems, by O. L. Giersch, Duke Pwr. Co.; High-Speed Protective Relays, by A. R. Van C. Warrington, Genl. Elec. Co. Dinner preceding meeting addressed by L. S. O'Roark of the Bell Tel. Lab., Inc., N. Y., on Experiments in Speech and Music. Those elected to take office Jan. 1, 1932, were announced as follows: J. E. Lear, *chairman*; R. L. Stainback, *secy.-treas.*; E. P. Coles, Raymond Hunt, J. E. S. Thorpe, and J. H. Paget, *members exec. committee*. Nov. 10. Att. 115.

Oklahoma City

The Arthur S. Huey Memorial Station, by Otis Howard, Oklahoma Gas & Elec. Co. Inspection trip through the station followed. Oct. 30. Att. 60.

International Telephone Service, by H. S. Osborne, Am. Tel. & Tel. Co., N. Y. Dinner meeting. Nov. 20. Att. 85.

Philadelphia

Air Conditioning, by J. F. Gaskill, Phila. Elec. Co. Nov. 9. Att. 185.

Pittsburgh

Lightning Protection of Overhead Transmission Systems, by W. W. Lewis, Genl. Elec. Co. Joint meeting with the Engineers' Soc. of Western Pa. Nov. 10. Att. 171.

Pittsfield

Electrical Research, by E. L. Manning, Genl. Elec. Co. Demonstrations. Dinner meeting. Nov. 3. Att. 950.

Fused Quartz, by P. K. Devers, Genl. Elec. Co. Illustrated. Dinner meeting. Nov. 17. Att. 250.

St. Louis

International Telephone Service, by H. S. Osborne, Am. Tel. & Tel. Co., N. Y. Nov. 18. Att. 78.

San Antonio

International Telephone Service, by H. S. Osborne, Am. Tel. & Tel. Co., N. Y. Illustrated. Nov. 24. Att. 68.

Schenectady

Annual meeting. Oct. 8. Att. 90.

Construction of the George Washington Bridge, by E. W. Stearns, Port of New York Authority. Illustrated. Joint meeting with A.S.M.E. Oct. 29. Att. 250.

Human Engineering, by Col. C. R. Gow, Warren Brothers Co., and prof. of humanics at M.I.T. Joint meeting with the A.S.M.E. Nov. 19. Att. 260.

The Autogiro, by A. E. Larsen, Autogiro Co. of America. Moving pictures. Joint meeting with the A.S.M.E. Dec. 10. Att. 320.

Seattle

The Skagit River Power Development, by J. D. Ross, supt. of lighting, City of Seattle. Illustrated. Dinner meeting. Nov. 17. Att. 85.

Spokane

Advantages of the New Cascade Tunnel and Main Line Electrification of the Great Northern Railway, by Glen Walker, Great Northern Co. Film—"Electrified Operation of Trains." Nov. 27. Att. 52.

Syracuse

Trends in Improvement of Electric Service, by F. A. Hamilton, Jr., Genl. Elec. Co. Slides and moving pictures. Oct. 26. Att. 168.

Toledo

Electrons at Work and at Play, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Joint meeting with the Affiliated Tech. Societies of Toledo. Nov. 12. Att. 1,200.

System Operation, by F. H. Dubs, Toledo Edison Co.; Power Transformer Design and Tap Changing Under Load, by L. H. Hill, Allis-Chalmers Co. Considerable discussion. Nov. 20. Att. 80.

Toronto

Recent Developments in Oil Circuit Breakers, by G. R. Langley, Canadian Genl. Elec. Co. Moving pictures and slides. Nov. 13. Att. 124.

Circuit Breakers for Branch Circuits, by O. S. Jennings, Westinghouse Elec. & Mfg. Co. Demonstrations. Nov. 27. Att. 100.

Urbana

Contribution of the Physical Sciences to Human Welfare, by Prof. C. T. Knipp, Univ. Illinois. Demonstrations. Nov. 17. Att. 58.

Washington

Registration of Engineers, by Dr. W. B. Kouwenhoven of the Johns Hopkins Univ. (Baltimore) vice-pres. A.I.E.E. Dinner meeting. Nov. 10. Att. 65.

Worcester

Uses of the Thyratron Tube, by R. H. Rogers, Genl. Elec. Co. Nov. 12. Att. 60.

Past Branch Meetings

University of Alabama

Joint meeting A.S.C.E. chapter—motion pictures and talks by students. Nov. 16. Att. 40.

University of Arizona

Electronic Music, by T. S. Henderson, student. Oct. 16. Att. 5.

Carrier Waves, by C. A. Ferguson, Am. Tel. & Tel. Co. Dinner meeting. Oct. 23. Att. 14.

Thomas Alva Edison, by H. P. McGovern, student. Illustrated. Oct. 30. Att. 7.

The Electron Tube Voltmeter and Ammeter, and the Phase Shifting Bridge, by P. F. Hawley, student. Nov. 6. Att. 7. Film—"The Single Ridge." Nov. 13. Att. 6.

University of Arkansas

Lead Acid Batteries, by H. H. Lewis, student; Storage Battery Application, by Erle Cato, student; Review of the Electrical World, by Luther Hildebrand, student; Resistance, by Eugene Ray, student; The Life and Works of Edison, by L. Wasson, student. Nov. 11. Att. 38.

Magnetism, by E. E. Boreland, student; Illumination of Athletic Fields, by F. L. McDonald, student; Research Work, by J. H. Nelson, student. Dec. 2. Att. 42.

Armour Institute of Technology

Transmission of Pictures by Wire, by S. R. Sjoderberg, Am. Tel. & Tel. Co., assisted

by E. E. Albin. Illustrated. Nov. 7. Att. 65.

Two-Speed Continuous Automatic System, by E. G. Stecher, Chicago and Northwestern RR. Co. Illustrated. Nov. 21. Att. 65.

Film—"The Electric Ship." Dec. 4. Att. 65.

University of British Columbia

The Thury System of D-C. Distribution, by G. G. Henderson, student; The Control of High Frequency Oscillators by Means of Quartz Crystals, by A. C. Tregidga, student. Nov. 16. Att. 9.

Brooklyn Polytechnic Institute

The Problems Confronted in the Design of a Commercial Short-Wave Receiver for Operation from A. C. Mains, by L. A. DeRosa, student; The Theory of the InductionVoltage Regulator, by Frank Anderson, student. Dec. 2. Att. 19.

Bucknell University

Prof. G. A. Irland, counselor, discussed the aims and activities of the A.I.E.E. and stressed the importance of student enrolment. J. A. Everitt elected secy.-treas. Nov. 4. Att. 14.

California Institute of Technology

J. R. Howell, Sterling Motor Co., described the characteristics and construction of sterling motors. Nov. 18. Att. 36.

University of California

Construction Features of the Hoover Dam, by W. C. Johnson, Westinghouse Elec. & Mfg. Co. Three students presented papers on the life of Michael Faraday. Nov. 10. Att. 31.

Short Cuts in Complex Numbers, by W. J. McLeod, student. Films—"Big Deeds" and "Power Transformers." Nov. 24. Att. 42.

Election of officers: J. J. Cassidy, *chairman*; H. C. Kruger, *vice-chairman*; S. L. Bettis, *secy.*; C. P. Van Camp, *treas.* Dec. 2. Att. 9.

Carnegie Institute of Technology

Switchboards and the Work of the Switchboard Engineer, by A. J. Peterson, Westinghouse Elec. & Mfg. Co. Nov. 13. Att. 36.

Case School of Applied Science

Resuscitation from Electric Shock, by G. E. Smith, Ohio Bell Tel. Co. Dinner meeting. Dec. 3. Att. 29.

Catholic University of America

H. G. Dorsey, U.S. Coast & Geodetic Survey, showed slides illustrating wiring diagrams of the "fathom meter," used to find the depth of water at desired points. Nov. 12. Att. 39.

University of Cincinnati

The Application of Fuses to Electrical Distribution Systems, by Frank Sanford, Union Gas & Elec. Co. Nov. 11. Att. 65.

Clemson Agricultural College

Practises that Improve the Operation of Electrical Equipment, by C. P. Walker, student. Illustrated lecture on the Genl. Elec. Co. by V. L. Bethea, student. Nov. 5. Att. 40.

Prof. C. M. Asbill gave a talk on radio. Current events presented by J. L. O. Foster, student Nov. 19. Att. 35.

Colorado State Agricultural College

Post Graduate Work and Advanced Degrees, by Prof. H. G. Jordan. Dale Pinkerton elected secy. Nov. 9. Att. 24.

University of Colorado

Film—"The Story of Nitrocellulose." Nov. 18. Att. 61.

Cornell University

The aims and activities of the A.I.E.E. were outlined by Prof. P. M. Lincoln and Prof. R. F. Chamberlain. Nov. 6. Att. 33.

University of Denver

Inspection trip to the Valmont plant of the Pub. Serv. Co. of Colo. Nov. 7. Att. 13.

The Effect of Physical Stresses on Magnetic Materials, by Martin Eisendorfer. Dec. 1. Att. 14.

University of Detroit

Set Checkers and Radio Maintenance, by J. C. Hoover, Hoover Lab., Inc. Film—"Wizardy of Wireless." Nov. 12. Att. 60.

Drexel Institute

Problems of Modern Physics, by Dr. T. H. Johnson, asst. director, Bartol Research Lab. of Swarthmore College. Nov. 19. Att. 36.

Duke University

Debate, in which four students participated: Resolved: That Hydro Power is More Economical for the Generation of Electric Power than Steam Power. Nov. 19. Att. 20.

University of Florida

Power Distribution for Rapid Transit Lines and Dynamic Braking, by F. B. Gaines, student. Film—"Making of Mazda Lamps." Nov. 18. Att. 45.

Development of the College of Engineering at the University of Florida, by Howard Rybolt, student. Dec. 3. Att. 100.

Georgia School of Technology

Three films: "Thomas A. Edison," "Liquid Air," and "How the General Electric Icing Unit Works." Nov. 10. Att. 55.

Harvard University

Some Rocks Ahead, by Prof. Philip Cabot. Nov. 19. Att. 77.

University of Illinois

Film—"Dynamic America." Nov. 11. Att. 40.

University of Iowa

Multi-Mu and Pentode Tubes, by Wendell Seward, student; Induction Furnace, by Jack Sayer, student; Life and Works of Thomas Edison, by Leonard Sahs, student. Oct. 28. Att. 41.

Some Acoustical Problems of Electrical Engineering, by Harold Petersen, student; Modern Street Lighting Practise, by R. K. Meyer, student. Nov. 4. Att. 39.

Film—"The Single Ridge." Nov. 18. Att. 42.

Kansas State College

Talk by Arthur Groesbeck of the United Pwr. & Lt. Corp. Moving pictures. Nov. 5. Att. 54. Afternoon meeting. Program repeated same evening. Att. 33.

The Engineer's Work in a Power Company, by Ivan Buys, United Pwr. & Lt. Corp. Dec. 3. Att. 54. Afternoon meeting. Program repeated same evening. Att. 36.

University of Kansas

Several 1-min. talks by students and faculty members. Nov. 19. Att. 20.

University of Kentucky

Southern California Power Development, by Prof. E. A. Bureau. Nov. 18. Att. 41.

Lafayette College

The Bulls Bridge Hydroelectric Power Development, by Richard Brunn, student. Illustrated. November 20. Att. 14.

Lehigh University

Thomas Alva Edison, by Sidney Land, student. Illustrated; Four Months in Europe, by Dean Joseph W. Barker, Columbia Univ. Nov. 19. Att. 85.

Lewis Institute

The Routine of a Telephone Call, by L. P. Evans, student; The Handling of a Telegram, by M. H. Dressler, student. Nov. 16. Att. 50.

University of Louisville

Sound Equipment, by C. C. Baines, Samson Elec. Co. Demonstrations of sound apparatus. Nov. 13. Att. 26.

University of Maine

R. E. Young, chairman, outlined the activities at the district meeting held in Rochester in April, 1931. Prof. W. E. Barrows outlined his experiences at the silver jubilee of the Illuminating Engg. Soc. held at Pittsburgh. Oct. 22. Att. 24.

Thomas Edison's Life and Work, by Raymond Hunter, student; Faraday's Life and Work, by Henry Howes, student. Nov. 12. Att. 16.

Massachusetts Institute of Technology

Inspection trip through the plant and laboratories of the Simplex Wire & Cable Co. Nov. 4. Att. 30.

The Generation and Distribution of Electric Power, by E. S. Mansfield, Edison Elec. Illum. Co. of Boston. Film—"More Power to You." Nov. 19. Att. 225.

Inspection trip to the Edgar station of the Edison Elec. Illum. Co. of Boston at South Weymouth. Nov. 23. Att. 25.

Michigan College of Mining and Technology

W. D. Stewart, student, gave an illustrated lecture on turbo-generators. Equipment and Operation of Radio Station WHDF at Calumet, Mich., by K. M. Smith, student. Nov. 19. Att. 31.

Michigan State College

Experiences in Russia, by Mr. McElroy. Joint meeting with A.S.C.E. and A.S.M.E. Branches. Nov. 12. Att. 23.

A Day in the Weather Bureau, by Prof. Seelye, U.S. Weather Bur. at East Lansing. Dec. 8. Att. 24.

University of Michigan

The Placement, Training, and Eventual Work of the Engineering Graduate, by W. A. Furst, Westinghouse Elec. & Mfg. Co. Nov. 24. Att. 102.

Missouri School of Mines and Metallurgy

L. K. Johnson, student, outlined his experiences while employed by the Genl. Elec. Co. Nov. 4. Att. 16.

Demonstrations. Nov. 18. Att. 15.

Montana State College

General Electric Training, by George Lamb; Radio Transmitter Filter Circuits, by H. L. Casey; Nature's Freak—Ball Lightning, by P. B. McAdam, student; The Way to Prosperity and Progress, by C. E. Grunsky, taken from the Oct. 1931 issue of Electrical Engineering, presented by Wm. H. Scheele, student. Nov. 5. Att. 103.

Montana Section as guests of the Branch witnessed displays and demonstrations presented by students. Refreshments. Nov. 19. Att. 462.

University of Nebraska

Inspection trip through the offices of Dr. R. L. Smith; X-ray equipment displayed and uses demonstrated. Nov. 4. Att. 50.

Newark College of Engineering

Development of Television, by G. R. Ottinger, N. J. Bell Tel. Co. Illustrated. Nov. 23. Att. 46.

University of New Hampshire

Michael Faraday's Rise to Fame, by H. L. Wood, student; Combating Magnetism in Watches, by B. Booth, student; The Physical Analysis of Water Coming from a Paper Mill, by L. A. Barker, student; The Advancement of the Turbo-Generator, by J. L. Currier, student. Oct. 3. Att. 32.

The Development of the Microphone, by O. F. Cushman, student; Electricity in Agriculture in Sweden, by H. T. Dickson, student; Another Cure for the Business Depression, by A. E. Dogan, student. Oct. 17. Att. 25.

G. L. Freese, student, described the new bridge to be constructed between Newington and Durham; Functions and Benefits of the A.I.E.E., by P. A. Rolfe, student. Oct. 24. Att. 29.

Illumination of the Home, by C. M. Glidden, New Hampshire Gas & Elec. Co. Illustrated. Nov. 7. Att. 33.

Some of the Problems in the Distribution Department at Cambridge, Mass., by James Allen, New England Gas & Elec. Co. Nov. 18. Att. 45.

University of New Mexico

M. A. True, chairman, outlined the aims and activities of the A.I.E.E. Nov. 6. Att. 33.

HISTORY AND THEORY OF ELECTRICAL PRECIPITATION OF SOLIDS FROM GASES, by S. O. Fish, student. Nov. 17. Att. 18.

New York University

RELAYS, by G. M. Heckel, student; ARC WELDING, by L. Lindorf, student. Oct. 27. Att. 14.

University of North Carolina

CALCULATION OF THREE-PHASE SHORT-CIRCUIT CURRENTS, by O. L. Giersch, Duke Pwr. Co. Nov. 12. Att. 35.

University of North Dakota

MICHAEL FARADAY, by E. Besken, student; JOSEPH HENRY, by Geo. Anderson, student. Nov. 11. Att. 10.

University of Notre Dame

THE USE OF TRANSFORMERS IN TELEPHONY, by Henry Cluver, student; THE MANUFACTURE OF SOUND EQUIPMENT, by H. H. Shotwell, Operadio Mfg. Co. John Scanlon, student, presented the bi-monthly engg. digest. Nov. 16. Att. 75.

NEON SIGNS AS USED IN ADVERTISING, by E. W. Kenefake, student; COMMERCIAL ILLUMINATION, by O. P. Cleaver, Westinghouse Elec. & Mfg. Co. John Scanlon, student, presented the engg. digest. Nov. 30. Att. 65.

Ohio State University

Several students gave talks in commemoration of Michael Faraday. Dinner meeting. Nov. 5. Att. 18.

SOME INSTITUTE PROBLEMS AND THE ELECTRICAL INDUSTRY, by Dr. C. E. Skinner, pres. A.I.E.E., and asst. director of engg., Westinghouse Elec. & Mfg. Co. Dinner meeting. Nov. 20. Att. 50.

Ohio University

MAKING ELECTRICAL TRANSCRIPTIONS, by Prof. D. B. Green. Nov. 11. Att. 44.

Prof. W. H. Cooper gave a talk in which he compared the engg. students with students of other professions. Dinner meeting. Dec. 9. Att. 46.

Oklahoma A. & M. College

THOMAS A. EDISON, by E. E. Moore, student. Nov. 9. Att. 24.

Pennsylvania State College

Four students outlined their experiences during summer employment. Oct. 28. Att. 23.

WHY AUTO AXLES BREAK, by Dr. E. C. Woodruff. Nov. 18. Att. 90.

University of Pittsburgh

R. E. Bishop, student, outlined his experiences while doing cooperative work with the Ohio Pwr. Co. Oct. 29. Att. 121.

LIFE AND WORK OF THOMAS EDISON, by T. Namlick, student; REPORT ON ACADEMY OF ARTS AND SCIENCES, by J. V. Heisch, student. Nov. 5. Att. 121.

COPPER OXIDE RECTIFIERS, by H. L. Lammy, student. Nov. 12. Att. 122.

SECRET SERVICE SYSTEM, by G. S. Onori, student. Nov. 19. Att. 120.

Pratt Institute

HISTORICAL DEVELOPMENT OF MODERN PHYSICAL THEORIES, by J. E. Thompson. Nov. 5. Att. 74.

MANUFACTURE AND TESTING OF WARD-LEONARD VITROHM RESISTORS, by H.F.McCord, student. Nov. 19. Att. 31.

SOUND REPRODUCTION IN TALKING PICTURES, by O. W. Hancock, student. Dec. 3. Att. 20.

Princeton University

THYRATRON COMMUTATOR MOTOR, by Prof. C. H. Willis. Nov. 23. Att. 12.

COMMUNICATION PROBLEMS OF POWER UTILITIES, by L. K. Wyatt, student; PENNSYLVANIA ELECTRIFICATION, by L. Thomas, student; LIGHTNING ARRESTERS, by M. Kine, student. Dec. 9. Att. 6.

Rensselaer Polytechnic Institute

SOME PICTURESQUE SPOTS IN THE DEVELOPMENT OF THE INCANDESCENT LAMP, by Samuel Ferguson, Hartford Elect. Lt. Co. Nov. 17. Att. 120.

Rhode Island State College

ELECTRIC WELDING, by L. C. Breault and B. Porter, students. Oct. 15. Att. 21.

LAGGING OF WATTHOUR METERS, by Mr. Mobrey. Nov. 5. Att. 34.

LIFE OF THOMAS A. EDISON, by L. M. Lang, student. Illustrated. Nov. 12. Att. 17.

AIRPORT LIGHTING, by Geo. Freeman, student; RADIO COMMUNICATION ON TRAINS, by Edward Long, student. Nov. 19. Att. 15.

The Rice Institute

Film—"Power." Nov. 18. Att. 21.

General discussion. Dec. 3. Att. 13.

Rose Polytechnic Institute

LIFE OF FARADAY, by Wm. Hineline, student. Nov. 25. Att. 36.

Film—"The Magic Circle." Dec. 7. Att. 101.

University of Santa Clara

Film—"Modern Methods of Riveting." Joint meeting with A.S.M.E. Branch. Nov. 12. Att. 104.

Report of San Francisco A.S.M.E. and A.S.C.E. Section meetings given respectively by Gale Sullivan and A. Porter, students. Joint meeting with A.S.M.E. and A.S.C.E. Branches. Nov. 19. Att. 95.

University of South Carolina

Film—"Thomas A. Edison," Nov. 5. Att. 42.

Business meeting. Nov. 12. Att. 11.

SANTEE RIVER HYDROELECTRIC PROJECT, by L. E. Rankin, student; APPLICATION OF FOURIER'S SERIES TO DISTORTED CURRENT WAVES, by W. S. Smith, student; HYDROELECTRIC PROJECT ON BROAD RIVER, by A. B. URQUHART, student. Nov. 19. Att. 43.

South Dakota State School of Mines

INDUSTRIAL CONTROL, by F. H. Doremus, Genl. Elec. Co.; THE MODERN TREND IN STEAM TURBINE DESIGN, by R. A. Halse, Genl. Elec. Co. Nov. 4. Att. 37.

University of Southern California

E. R. Stauffacher, So. California Edison Co., Ltd., described relay applications on the Edison system. Oct. 27. Att. 31.

M. W. Edwards, Municipal Lt. and Pwr. Dept., City of Pasadena, spoke on the development and expansion of their power plant and interconnecting systems. Nov. 4. Att. 25.

Stevens Institute of Technology

MOTORLESS AVIATION, by H. W. Braendel, student. Nov. 13. Att. 40.

University of Utah

INVENTIONS OF THOMAS A. EDISON, by S. Ramo, student; DEVELOPMENT OF THE INCANDESCENT LAMP, by F. C. Derrick, student. Nov. 5. Att. 30.

SALESMANSHIP AS RELATED TO ENGINEERING, by Mr. Ferguson, Utah Pwr. & Lt. Co. Nov. 19. Att. 35.

University of Vermont

Prof. L. P. Dickinson, counselor, gave an illustrated lecture on the life and work of Thomas A. Edison. Oct. 26. Att. 20.

VARIOUS TYPES OF A-C. RECTIFIERS, by Prof. L. P. Dickinson, counselor. Nov. 9. Att. 18.

Virginia Military Institute

LIFE OF EDISON, by W. S. Hayman, student; MODERN ELECTRICITY, by W. L. Calhoun, student; LIFE OF STEINMETZ, by F. B. Epps, student; LIGHTNING ELECTRICITY, by N. W.Lingman, student. Nov. 14. Att. 57.

Virginia Polytechnic Institute

HARDENING METALS BY MAGNETISM, by A. de Villesante, student; POWER PLANT OF THE AKRON, by R. C. Beverly, student; BOULDER DAM, by C. Gratz, student. Nov. 11. Att. 50.

RECTIFICATION OF ALTERNATING CURRENT, by D. E. Williams, student; VIRGINIAN RAILWAY POWER PLANT AT NARROWS, VA., by C. R. Settle, student. Nov. 19. Att. 47.

State College of Washington

Dean H. V. Carpenter, vice-pres. A.I.E.E., reviewed activities at the 1931 Pacific Coast convention. Oct. 27. Att. 22.

LIFE AND WORKS OF THOMAS A. EDISON, by D. H. Olney, student. Nov. 17. Att. 34.

University of Washington

Captain Crim, U.S. Army Ordnance, described methods of electrical firing control. Illustrated. Nov. 12. Att. 27.

PHOTOELECTRIC CELLS AND THEIR APPLICATION TO SOUND REPRODUCTION, by Floyd Norris, student. Nov. 19. Att. 13.

ROCK ISLAND PROJECT ON THE COLUMBIA RIVER, by L. R. Coffin, Puget Sound Pr. & Lt. Co. Dec. 3. Att. 19.

West Virginia University

RURAL POWER TRANSMISSION, by L. E. Palmer; ARC WELDING, by Wm. P. McCue; WAYS OF PROVING GOOD WELDS, by R. W. Blair; D-C. CONTROLLED RELAYS, by A. W. Friend; CIRCUIT BREAKERS IN THE HOME, by J. L. Simpson; TRANSMISSION AND DISTRIBUTION OF ELECTRIC ENERGY, by J. E.Wallace, all students. Nov. 9. Att. 30.

MODERN PRACTISES IN THE USE OF ELECTRIC POWER, by M. Stewart; THE EARTH'S ELECTRIC CHARGE, by F. D. Brown; NIGHT PHOTOGRAPHY, by E. P. McCue; ELECTRICAL APPLIANCES AT THE NEMACOLIN MINE, by V. Montieth; WELDED BUILDING CONSTRUCTION, by A. Higgins; all students. Nov. 2. Att. 30.

THOMAS A. EDISON, by Philip Skaff, student. Illustrated. Film—"The Single Ridge," Nov. 9. Att. 30.

University of Wisconsin

THYRATRON TUBES, by C. V. Bullen, student; CALCULATION OF MAGNETIC FLUX DENSITY, by K. J. Rhodes, student. Nov. 9. Att. 67.

University of Wyoming

THEORETICAL FUNCTIONING OF GASEOUS TUBES USED FOR ILLUMINATION, by Albert Buchholz and LeRoy Border, students; PRACTICAL APPLICATION OF GASEOUS TUBES USED FOR ILLUMINATION, by H. Soule, Western Pub. Ser. Co. Nov. 17. Att. 25.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Balaguer, Manuel M.,c/o International Tel. & Tel. Co.,67 Broad St.,New York, N. Y.
Cater, C.,Sandal, Church Road, Pinner, Eng.
Chilofsky, Joseph, 958 N. 7th St.,Phila. Pa.
Cordier, N.A., 126 Chatterton Pkwy., White Plains, N. Y.
Farnlof, Charles G.T.,1318 Laketon Rd.,Wilkinsburg, Pa.
Gaylord, R.H.,1814 Virginia Rd.,Los Angeles, Calif.
Goldsman, Jacob L.,64 Priory Rd.,Hampstead, London, Eng.
Kamm, J. Lloyd, 1801 N. Lamar St.,Dallas, Texas.
McCulloch, G.B.,McVie Caterers, Ltd.,Sydney, N.S.W.,Australia.
Melson, Sydney W.,Yeatton Woolrich Rd., Abbey Wood, London, S.E.2, England.
Mountain, C.E.,Burma Elec. Supply Co.,Mandalay, Burma, India.

Parr, J.C.,245-71st St., Bklyn.,N.Y.
Pierson, Walter D.,4710 Locust St.,Phila. Pa.
Pistorius, L.H., 193 Jeppe St., Johannesburg, South Africa.
Schrock, John E.,3720 Main St.,Lawrence Park, Erie, Pa.
Stempfle, Frederick, 8126 E. Vernor Highway, Detroit, Mich.
Tate, William, Apartado No. 41, Pula, Mexico.
Thakkur, K.B.,Box 654, Whiting, Ind.
Voronovsky, T.G.,1162 Waverly Place,Schenectady, N.Y.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

GRAD. E. E., 24, single, B.S. in E. E., W.P.I. 1931; 4 yr. experience in construction; one in transmission work. Desires work in any E.E. field. Available at once. Location optional. D-45.

1931 GRAD. E.E. of 5-yr. cooperative school, 23, single. Experience includes machine shop practise, telephone central office trouble shooting, and service with large municipal fire alarm system. Desires position with mfg. concern or pub. utility. Will start at bottom. Middle West preferred, elsewhere satisfactory. C-9825.

DESIGN ENGR., col. grad., 38, married; 9 yr. elec. substation and powerhouse design, with switchboards, wiring diagrams, and all other important items; 5 yr. test engr. pwr. station and research labs. Fluently speaks Spanish, German, and Hungarian. Available immediately. U.S.A. or foreign. C-9128.

FINANCIAL ENGR., Cornell (ME-EE); 12 yr. regulatory commission; 4 with utility holding mgnt. corp., 8 months intensive course bond buying dept. leading insurance company; employed almost 4 yr. thereafter on financial and fact-finding investigations by outstanding cons. engg. organization. Desires opportunity New York City. Salary open. C-2953.

M.I.T. GRAD. E.E., 35, married. 6 yr. industrial and teaching experience in E.E. Several years private research and dev. work on own initiative. Good ability, integrity, and personality. Desires univ. teaching for life work. Mid West or South preferred. C-2826.

E.E., grad. southern univ., married, 34, G.E. Test; 10 yr. in utility engg. and maintenance work, (8 on underground distr. system incl. a-c. low voltage networks); desires position with utility in design or maintenance of distr. system. Location immaterial. C-1191.

GRAD. E.E., 26; 9 yr. consisting of power plant and substation constr. and maintenance as draftsman and engg. asst.; street ry. electrolysis surveys; automatic substation design and supervision of construction and maintenance; industrial elect. work as draftsman and engg. asst. Location immaterial. Available at once. C-5151.

ELECT-MECH. ENGR., 28, married, M.E. deg., thoroughly competent mech. and elect. design and dev. of rotating apparatus. First-class references and record of accomplishments. Available on notice. Location immaterial. D-109.

ELECT. ENGR. B.S. from M.I.T. in 1931. American, 25, single. Desires position with mfg. or pub. utility company. Upbringing in business environments qualifies him for sales work also. Eastern states preferred, any other location considered. Available now. D-110.

GRAD. E.E., 21, single, B.S. in E.E. 1931 high scholastic record. Summer experience pub. utility. Interested in position with industrial concern or pub. utility. Available now. New York preferred but not essential. C-9467.

TECH. GRAD. eastern college, B.S. in E.E., 1927. Good tech. background. Knowledge of vacuum tubes, audio amplifiers, and sound reproducing systems. Elect. pwr. distr. and refrig. Traveled extensively as company engr. and representative. Experienced in managerial, executive, sales capacities. Desires position requiring tech. ability and sales personality. C-8231.

MOTOR CONTROL EQUIPMENT ENGR. 25 yr. experience in motor control design, particularly elect. elevator and misc. control problems and layouts. B.S. in E.E. D-120.

RESEARCH ENGR. member A.I.E.E., A.S.M.E., Am. Statistical Soc.; lately with large utility company; change due to organization curtailment. D-112.

SUPERINTENDENT. 20 yr. in the States in constr. and operation of ry., lt. and pwr. properties; 8 yr. similar work in Latin America. Working knowledge of French, Spanish, Portugese. Successful mgt. sales eastern Cuba for large importers. Prefers Latin countries. B-5729.

GRAD. E.E., 1925; 27, single; 1 yr. G.E. Test. 5 yr. engg. dept. of large lt. and pwr. utility. Constr., inspection, investigations, and tests. Desires constr. or sales engg. work, but would consider anything. Location East. Available at once. D-107

ELECT., DESIGNING DRAFTSMAN, 37, married. 3 yr. Armour Inst., night school, E.E. 9 yr. design of stm. and hydroelect. sta. High and low voltage, substations and steel tower trans. lines, 1 yr. field engr. on trans. lines, 4 yr. constr. workman, 2 yr. operating and load dispatcher. Available now. Anywhere. C-9986-3660-Chicago.

MECH. AND ELECT. ENGR., 32, single, M.E. and E.E. 4 yr. instructor in machine design at Cornell University. 5 yr. Allis Chalmers stm. turb. design and checking, liberal shop experience. Desires at once responsible work offering future opportunities. Middle West preferred. D-122-3680-Chicago.

GRAD. E.E., 31, single, 8 yr. experience, design, and constr. of trans. lines, voltages up to, and incl. 220-kv., outdoor and indoor high voltage substation and distr. networks. Desires position in engg. or constr. dept. of large utility or holding company. Location immaterial. C-3564.

DESIGN ENGR., Westinghouse Engg. and Design School grad. Pwr. and instr. trans. design experience. Now employed. D-131.

SALESMAN, contact representative or mfr. agent; 37, experienced E.E. representative desires position with high grade company mfg. line of high or low voltage equip. for industrial plants or utilities. B-4067.

1931 E.E. Grad., Georgia Tech., cooperative plan. Single, 24, no obligations; 2½ yr. experience battery work; small turbo-generators; installation of pwr. and control equip. machine shops and oil pumping stations, and winding of fractional hp. motors. 4-yr. course Spanish. Available immediately, anywhere. D-127-3694-Chicago.

ELECT. ENGR. 32, single, B.S. E.E., additional work M.E., Phi Kappa Phi. 8 yr. board experience, powerhouse, substation, trans. line, duct system design; estimates, standards, equip. specifications, operation. Responsible, capable engineer asst. Desires position with mfr. or in plant mgnt. for utilities. Salary secondary to opportunity. D-124.

GRAD. ENGR., 41, with mech., structural and elect. experience. 10 yr. with engg. firms handling design and constr. of power and industrial plants. 2 yr. as plant engr. in large factory. Last 5 yr. with pub. utility on indoor and outdoor substations. Unemployed. A-3027.

ELECT. ENGR. 1924 grad., B.S. E.E., 29, married, 7 yr. experience testing, inspecting, installing various elect. equip. Writing reports. Asst. to mgr. pwr. and lt. utility. Purchasing elect. supplies. Available at once. Detailed information gladly given. Welcomes opportunity in operating-maintenance dept., pub. utility or mfg. concern. C-4981.

1931 E.E. GRAD. 6 yr. experience as an amateur radio operator. Experienced in radio receiving and transmitting apparatus. Desires position with radio or telephone concern. Available at once. D-76.

ELECT. ENGR. 30, married, B.S. E.E. 1924. 7 yr. experience design of synchronous motors, generators, condensers, frequency-changers of all speeds, ratings. Familiar with mech. design of synchronous machines and system stability studies. Desires employment with utility company or cons. engg. firm. Location immaterial. One month's notice. D-147.

ELECT. AND ILLUM. ENGR. member A.I.E.E., I.E.S., 16 yr. practical experience, electrician and mechanic, foreman, supt., etc. 10 yr. est. engg. for architects, etc. Some htg. and vent. experience. All around mechanic and electrician, draftsman. Wants work of some kind anywhere; eastern states preferred. C-8460.

GRAD. E.E., 22, single, B.S. E.E. 1931; two yr. experience in mfr. elect. motors and generators, constr., test, and experimental laboratory. Desires connection for design and constr. of generating plants. Prefers New Jersey, but not essential. D-159.

ELECT. ENGR. single, 26, E.E. '30. 15 months G.E. Test. 5 months experience in G.E. Research Laboratory. Desires position in engg. or test dept. of utility or mfg. company. Available at once. Location New York. D-136.

1931 GRAD. E.E. from leading college in N.Y. State desires position in the elec. industry. Experience main motive, age 25. Several languages. Location U.S.A. or any foreign country. Available immediately. D-164.

SALES ENGR., grad. M.I.T. 1925 B.S. E.E. Design experience Penna. R.R. Co., Westinghouse Test, sales course. Sales experience,

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

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domestic and export elect. equip.; financial training. Desires sales position or one where combined tech. and commercial knowledge is advantageous. At present in New York City. C-1415.

ELECT.ENGR.28, with mech. and lab. experience. Wishes work especially in connection with elec. rys. Salary not important if work is within New York area. C-8424.

ELECT. ENGR. 24, graduate Calif. Inst. of Tech. 1931. Special training vacuum tubes and communications, also radio experience. Desires position in communications or allied fields. Will start at bottom. Location immaterial; available at once. D-171.

GENERAL ENGR. Univ. education. Westinghouse apprentice. Wide experience. 4 yr. responsible charge of pwr. and wtr. supply for large industrial corp., operating chain of plants. 7 yr. large engg. and constr. corp. Experienced in mech. design, test and operation of pwr. stations. D-172.

ELECT. ENGR. 28, single. Grad. Georgia Tech. '29, B.S. in E.E. and C.E. Westinghouse test floor, engg. school and design school. 1 yr. experience in turbine generator design, incl. dev. work. Desires position with future. Location immaterial. Available at once. C-9923.

ELECT. ENGR. univ. grad., 36, married. Background of 8 yr. experience elect. test. in field and lab. also in erecting equip. Additional 3½ yr. experience in test and manufacture of radio tubes. Desires position with mfr. or lab. Metropolitan New York preferred. Available now. B-8817.

GRAD. E.E. 25, single. B.S.'29 and M.S.'31 from M.I.T. 1 yr. G.E. Test; 4 summers gen'l maintenance work with telephone company. Available at once. Will go anywhere, to any position for which qualified. Salary secondary. D-175.

1931 GRAD. ENGR., with B.E., single, 23, American, desires position in the elect. industry with opportunity for advancement. Location immaterial. D-174.

1931 E.E. GRAD., 23, single, B.S. in E.E. at M.I.T. Summer experience in electric station of pub. utility company. Desires position with pub. utility, elect. or radio mfg. company, salary secondary. Available at once. D-180.

ELECT. ENGR., Cornell. G.E. shops. 5 yr. each: ry. elect. hydroelect. projects; heavy automotive and tractor design and operation; engg. investigations, reports South America, Orient; quantity production high voltage vacuum devices, photoelectric and neon tubes, plant equipment; director electrophysical lab. Geoelectrical surveys for water, ore; own complete equipment. C-7026.

EXECUTIVE, industrial physicist tech. grad. with diversified research experience and excellent engg. training. Desires position with American organization. Will consider opening as asst. to able engr. or business executive. B-8987.

ENGR. INSPECTOR, tech. grad., 19 yr. experience incl. test. and lab. work, valuation, mfg. prod., inspection and expediting production of elect. and mech. pwr. equip. Familiar with latest dev. in elect. pwr. equip. and transmission material. Past 9 yr. represented pub. utility company inspecting and expediting. Position desired. D-179.

GRAD. E. E., 1929, single, 23. 15 mo. as student engineer on G.E. test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with firm doing cons. or constr. work or with utility or manufacturer. Available at once. Location anywhere in U.S. C-8028.

POWER PLANT MGR., SUPT., desires to make change. Married, 33. 3 yr. E.E. course, broad experience, 2 yr. U.S. Navy, 2 yr. large elect. mfg. company, 5 yr. elect. engr. ins. company. 4 yr. power-plant constr., mgt. Middle West preferred; will consider other. Short notice desired. D-187.

ELECT. ENGR., 24, single, Iowa State College, 1931. Experience limited. Desires work with pub. utility or mfg. concern. Salary second to opportunity. Available now. Anywhere in U.S. C-9827.

GRAD. OF NORTH CAROLINA STATE COLLEGE, class '31, B.S. in E.E., desires connection with illuminating concern or work with photoelectric cells. Salary no consideration. Wishes to learn business from bottom up; staying with it. D-144.

GRAD. E.E., 32, single. 3 yr. Westinghouse Test. 7 yr. supervising power plants, substation, transmission line construction. 8 yr. engg. insp., purchasing, expediting, tracer, res. engr. and writing specifications. Excellent reference. Can handle responsibility. Wants connection with pub. utility, holding company, contractor or mfr. Available immediately. Location immaterial. B-9661.

GRAD. E.E., 22, single, B.S. in E.E., 1931, desires work where 5 yr. practical experience as electrician and radiotrician will be of value. C-9896.

ELECT. ENGR., 23, single, 1931 grad., E.E. from Bklyn. Polytechnic Inst. Desires position with electrical industry with an opportunity for advancement. Salary secondary. New York preferred; not essential. D-188.

ELECT. ENGR. 45, univ. grad., experienced in the various branches of elect. engg. work of pwr. companies incl. work for industrial customers, desires position with pwr. company or mfr. Permanent position desired, but will consider temporary work. B-1923.

GRAD. E.E., 24, cooperative college. Experience, design, manufacture, test, repair of indicating instruments, tube testers, a-c. and d-c. power instruments, special instruments, relays. Familiar with test, laboratory equipment. Good background for research or test. Also experience in production. Type of work secondary. Available at once. U.S., Canada. C-9585.

GRAD. E.E. 34, married, 13 yr. experience U.S.A., Europe, Latin America. Drafting, design, supt. of constr., elect. and mech., power plants, a-c. and d-c. substations, industrial electrifications, etc. Also some experience in design of elect. mach. Fluent Spanish. Will consider new field at reasonable salary. C-8553.

ENGG.-PRODUCTION demand close tie for efficiency. Has designed and regulated production in automatic devices, radio receivers, small motors. Also design field and factory high speed test equip. Familiar phonograph recording, vacuum tubes, lab. supervision, constr. E.E. degree, married, 30, locate New York vicinity. D-181.

RESEARCH, DEV. ENGR., 30, B.S. and E.E. Columbia and Harvard univ. 1 yr shop, 6 yr. test., research, development, patent experience on various electrical, electromechanical devices for domestic, industrial applications; proved and substantial record for original work. Engg. and sales promotion, good correspondent. Executive qualifications. A-1 character, personality. C-930.

TRAFFIC ENGR., grad. E.E., 12 yr. experience, pub. utility, municipal organizations in engineering, vehicular traffic control and fire alarm work. Thoroughly experienced, traffic surveys, planning, specifications, installation, etc. of traffic or fire alarm systems. Now completing traffic system in eastern city. Available immediately. B-9408.

ELECT. ENG., 33, married, B.S. E.E. 1921. 10 yr. automotive maintenance. G.E. Test. 3 yr. designing motors, generators, arc welding equipment. 3 yr. developing, designing automotive drive motors, generators, control. 3 yr. automotive development, maintenance bus, cab company. Interested, electrical, automotive, designing, maintenance. D-95.

GRAD. E.E., 46. 18 yr. experience in the manufacture of elect. wiring devices, incl. designing, development, test., estimating, cost and production work. 4 yr. with Underwriters Laboratories charge of branch office making inspections, tests, examinations and reports. Desires position with mfg. concern, inspection bureau or experimental laboratory. C-8449.

ELECT. ENGR., B.S. in E.E. 1928. 6 yr. operating experience in elect. pwr. plants, both hydro and stm., 4 yr. cost accounting, some test. and sales experience. Wishes position with elect. utility or mfg. concern. Single. Salary open. Location U.S. or foreign. C-7796.

Membership

Recommended for Transfer

The board of examiners, at its meeting of November 24, 1931, recommended the following Associates for transfer to the grade of Member. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Member

Board, Virgil Lee, vice-pres. and genl. supt.,Pub. Serv. Co. of Colo.,Denver
Brain, Vivian J.F.,ch. elec. engr.,Dept. of Pub. Wks.,Sydney, N.S.W.,Australia
Burt,Harvey A.,asst.supt.,hydro and trans.,Pub. Serv. Co. of Colo.,Denver, Colo.
Carlson, Victor H., asst. to elec. supt.,Chile Exploration Co.,Chile,S. A.
Carraway, Thomas W.,Grinnell Co.,Providence, R.I.
Cave, Jere Shunk, ch. engr.,The Venezuela Telephone Co.,Venezuela, S. A.
Dring, George S.,div. plant supt.,Am. Tel. & Tel. Co.,Denver, Colo.
Fenkhausen, Rudolph H.,supt.,pwr. dept.,Bethlehem Shipbuilding Corp.,San Francisco, Calif.
Field, Russell M.,section engr., Westinghouse Elec. & Mfg. Co.,Sharon, Pa.
Hardaway,Warren D.,supt.,hydroelec. prod. and trans.,Pub. Serv. Co. of Colorado, Denver
Hudson, Floyd E.,asst. planning engr.,Bangor Hydroelectric Co.,Bangor,Me.
Kreul, Albert H.,elec. maintenance and constr., Portland G. E. Co.,Portland, Ore.
Nichols, Benjamin H.,instructor, elec. engg., Oregon State College, Corvallis
Nolan, Thomas J.,system operator, Toledo Edison Co.,Toledo, Ohio
Rogers, Clarence E.,ch. engr.,Pacific Tel. & Tel. Co.,Seattle, Wash.
Ryan, Richard M.,elec. engr.,G. E. Co.,Kansas City, Mo.
Shirk, William B.,steel mill engr.,Westinghouse Elec. & Mfg. Co.,E. Pittsburgh, Pa.
Siniapkin, Nicholas M.,elec. engr.,State Architect's Office, Albany, N. Y.
Smith, Walter F.,Jr.,member of tech. staff, Bell Tel. Lab.,Inc.,New York
Sterne, William C.,pres.,Arvada Electric Co., Denver, Colo.
Wang, Meng, prof. of E.E., Shansi Univ.,China

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before January 31, 1932.

Ackerman,F.L.,Portalnd G. E. Co., Salem, Ore.
Allen,G.M.,Florida Pwr. Corp.,Brooksville
Allen,H.O.,United Elec. Lt. Co., Springfield, Mass.
Allen,R.I.,J.B.Stetson Univ.,DeLand, Fla.
Anderson,L.W.,Genl. Elect. Co., Louisville, Ky.
Armstrong,W.M.,Stanford Univ. Stanford Univ., Calif.
Ashkenazi,M.A.,Phila. Elect. Co., Pa.
Atwater,E.,Bell Tel. Labs., N.Y.C.
Aydelott,J.C. (Member)Genl.Elect.Co.,Erie, Pa.
Baer,W.K.,Underwriters Labs.,N.Y.C.
Bange,R.M.,N. Y. Edison Co.,N.Y.C.
Barrett,J.S.,20 Fair St.,Nantucket,Mass.
Barrett,R.E.,Jr.,Holyoke Wtr. Pwr. Co.,Mass.
Bartley,E.A.,Allis-Chalmers Mfg.Co.,West Allis, Wis.
Bassett,L.R.,Int'l. Business Mach. Corp., Rochester,N.Y.
Behrens,H.F.,Brooklyn Edison Co.,N.Y.
Bell, J. D., Jr., H.&G.Refrig. Co.,Columbia, S.C.
Berner,J.A.,Northern States Pwr. Co.,Minneapolis,Minn.
Biggi,J.F.A.,Westn. Union Tel. Co.,N.Y.C.
Biskeborn,M.C.,Bell Tel. Labs.,Inc.,N.Y.C.
Black,H.M.,Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Blackbourn,F.E.,Milwaukee Sch. of Engg.,Wis.
Bolze,J.N.,2730 Humphrey St.,E.Elmhurst,L.I., N.Y.
Bond,D.H.,New Orleans Pub. Serv. Inc.,La.
Border, G.M.,Bell Tel. Labs., N.Y.C.
Borngesser,R.H.,Dept. of City Transit,Phila.Pa.

Bost,W.A.,Texaco Prod. Co.,Tulsa,Okla.
Bostick, D. R.,Carolina Pwr. & Lt. Co.,Raleigh, N.C.
Bradley,W.T.,Dept. of City Transit, Phila., Pa.
Branch,G.R.,Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Brenneman,A.G.,Hydro-Elect.Pr.Comm.ofOnt., Hamilton, Ont., Can.
Brieger,E.W.,Univ. of Texas, Austin, Tex.
Brockmeyer,H.,Wis. Telephone Co.,Milwaukee, Wis.
Brouse,H.L.,Rutgers Univ.,New Brunswick,N.J
Bruse,C.B.,Purdue Univ.,W.Lafayette, Ind.
Buchhart,P.W.,Pa. RR. Co., Phila.,Pa.
Burgess, E.H.,N.Y. Central RR., Harmon,N.Y.
Burgess,T.J.,Hydro-Elect. Pr. Comm. of Ont., Hamilton, Ont.,Can.
Byrne, H.E.,Detroit Edison Co., Mich.
Callaghan,J.L.,City of Baton Rouge, La.
Carbray,F.J.,Bell Tel. Co. of Can.,Montreal, Que.,Can.
Cartwright,G.H.,Rollins Col.,Winter Park, Fla.
Cavanagh,G.,North Am. Lt. & Pwr. Co., Chicago, Ill.
Chabot,R.L.,Bell Tel. Co. of Pa.,Pittsburgh, Pa.
Chapin,E.W.,U.S. Dept. of Com.,Baltimore,Md.
Chapman,H.D., Hydro-Elect.Pr.Comm. of Ont., Toronto, Can.
Chatham,A.A.,Case Sch. of Ap. Science, Cleveland, Ohio
Chick,J.E.,(Member) Westinghouse Elec. & Mfg. Co.,Akron,Ohio
Cillie,C.D.,Int'l. G.E. Co.,Schenectady, N.Y.
Clark,N.C.,Univ. of South. Calif.,Los Angeles.
Cline,T.H.,Purdue Univ.,W. Lafayette, Ind.
Connelly,J.S.,N.Y. Telephone Co.,N.Y.C.
Cooper,W.T.,1514 North Shore Ave.,Chicago,Ill
Coryell,W.R.,Washington Univ.,St.Louis, Mo.
Countryman,C.,Coxsackie, N.Y.
Crenshaw,R.F.,Am. Tel. & Tel. Co.,Memphis, Tenn.
Daebler,O.F.,Philadelphia Elect. Co., Pa.
Datshkovsky,E.,1809 So. Ridgeway Ave.,Chicago, Ill.
Davis,E.R.,Duke Power Co.,Charlotte, N.C.
Davis,P.A.,Genl. Elec. Co.,Bridgeport, Conn.
Dean,J.E.,Detroit Edison Co., Mich.
Dempsey,E.J.,Linde Air Prod. Co.,N.Y.C.
Diehl,S.C.,Lehigh Univ.,Bethlehem, Pa.
DiIorio,F.,Jr.,217 Canal St.,Staten Island,N.Y.
DiJulio,F.,Lewis Inst. of Tech.,Chicago, Ill.
Douglass,G.W.(Member)N.J. Bell Tel. Co., Newark, N.J.
DuMont,P.J.,Genl.Elect.Co.,Schenectady, N.Y.
Dunlap,R.S.,Westinghouse Elec. & Mfg. Co., E. Pittsburgh,Pa.
Dyleswski,T.J.,Univ. of Cincinnati, Ohio
Earnhart,G.W. (Member) U.S.Dept. of Com., Denver, Colo.
Eastman,A.A.,G. E. Lt. Inst.,Cleveland, Ohio
Fenn,F.H.,Louisiana State Univ.,Baton Rouge, La.
Filman,P.T.,Pa. Pwr. & Lt. Co.,Williamsport
Fletcher,W.B.,Am. Tel. & Tel. Co., Providence, R.I.
Fletemeyer, L.H.,Jr., Roessler & Hasslacher Chemical Co., Niagara Falls, N.Y.
Forbes,A.D.,Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Frye,C.C.,Genl. Elec. Co.,Erie, Pa.
Gahagan,J.E.,United Elect. Lt.& Pr.Co.,N.Y.C.
Gardner,G.S. (Member) Asso. Tel. & Tel. Co., Chicago, Ill.
Gentilini,C.,Westinghouse Elec. & Mfg. Co., Wilkinsburg, Pa.
Ghamat,S.B., Sch. of Engg. of Milwaukee, Wis.
Goldberg,Y.,Des Moines Elec. Lt. Co.; Iowa Pr. & Lt. Co.,Ia.
Graham,H.E.,1230 E. 69th St.,Chicago, Ill.
Green,F.A.,Twin Coach Corp.,Kent, Ohio
Griffith,D.P.,718 Fifth St.,Catasauqua, Pa.
Gurley,G.H.,Univ. of Kans.,Lawrence, Kans.
Halbach,E.A.,Marquette Univ.,Milwaukee,Wis.
Hale,J.A.,Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Hall,J.R.,Allis-Chalmers Co.,W. Allis, Wis.
Hanley,C.M.,N. Y. Telephone Co.,N.Y.C.
Hannon,M.W.,Hoosier Pub. Utility Co.,Osgood, Ind.
Harrower,G.A.,325 Simpson St.,New Westminster, B.C., Can.
Hastad,C.J.,Bell Tel. Lab.,N.Y.C.
Hattox,J.G.,Worcester Poly. Inst.,Worcester, Mass.
Haydock,J.G.,Jr.,Philadelphia Elec. Co.,Pa.
Hazell,W.,Jr.,Diehl Mfg.Co.,Elizabethport,N.J.
Heckert,R.B.,Standolind Pipe Line Co.,Tulsa, Okla.
Heil,H.R.,Brooklyn Edison Co.,N.Y.
Henry,M.,(Member)Col. of the City of N. Y., N.Y.C.
HensleyM.S.,Am. Tel. & Tel. Co., Kansas City, Mo.
Hepler,K.G.,Carnegie Inst. of Tech., Pittsburgh, Pa.
Himebrook,F.S.,Ohio State Univ.,Columbus
Hoffman,E.C.,Naval Gun Factory, Washington, D.C.
Howard,W.S.,Luther Hill High School, May, Okla.
Huang,P.,Mass. Inst. of Tech.,Cambridge,Mass.
Hubbard,D.C.,Virginia Pub. Serv. Co.,Clifton Forge
Inslerman,H.E., Micamold Radio Corp.,Bklyn, N.Y.
Jackson,E.S.,Jr.,Consumers Pwr. Co.,Grand Rapids, Mich.
Janer,A.N.,530 W. 144th St.,New York, N.Y.
Jensen,W.H.,Genl. Elec. Co.,Schenectady, N.Y.
Jeryan,P.H.,RCA Victor Co.,Phila.,Pa.
Jones,A.A.,Anaconda Wire & Cable Co.,Hastings-on-Hudson, N.Y.
Jordan,S.R.,Univ. of Ill.,Urbana, Ill.
Kantayya,A.G.,Rensselaer Poly.Inst.,Troy,N.Y.
Keyuha,J.,West Virginia Univ.,Morgantown
Keaney,D.E.,Worcester Poly. Inst.,Mass.
Kelley,D.P.,Bell Tel. Lab.,N.Y.C.
Kennedy,E.D.,Rutgers Univ., New Brunswick, N.J.
Kennedy,F.H.,Jr.,Rensselaer Poly. Inst., Troy, N.Y.
Kinney,F.M.,R. R. No. 2, Clyde, Ohio
Knack,W.L.,Dunlop Tire & Rubber Co.,Buffalo, N.Y.
Kresser,J.V.,Westinghouse Elec. & Mfg. Co.,E. Pittsburgh, Pa.
Kunins,M.K.,U.S. Dept. of Com., Buffalo, N.Y
LaBarge,K.F.,Fisher Body Corp.,Detroit,Mich.
Langaunet,J.C.,W. Penn Pwr. Co.,Elizabeth,Pa.
Langenberg,G.W.,Genl. Elec. Co.,Fort Wayne, Ind.
Lantz,N.G.,Super-Power Co. of Illinois,Pekin
Latta,A.,Western Elec. Co.,Kearny,N.J.
Lauth,C.E.,719 North St.,E. Mauch Chunk, Pa.
Lewis,J.J.,Rensselaer Poly. Inst.,Troy, N.Y.
Lewis,R.C.,Iowa State College, Ames
Lincoln,P.R., Harvard Engg. Sch., Cambridge, Mass.
Looney,J.W.,Jr.,Hydro-Elect.Pr.Comm. of Ont., Port Arthur, Can.
Lugg,T.L.,Nat. Sound Serv. Bur.,New Augusta, Miss.
Lunn,E.O.,Turnbull Elevator Co.,Toronto,Ont., Can.
Lutzen,C.C.,Marquette Univ.,Milwaukee, Wis.
Lyle,R.E.,Westinghouse Elec. & Mfg. Co.,E. Pittsburgh, Pa.
Magers,O.N.,Bell Tel. Labs.,Inc.,N.Y.C.
Mantle,G.W.,B.C. Elect. Ry.Co.,Lake Buntzen, Burrard Inlet, B.C.,Can.
Markowitz,J.,2115 Washington Ave.,Bronx, N.Y.C.
Marks,H.W.,Taplet Mfg. Co.,Phila.,Pa.
Martin,T.G.(Member) Asso. Elect. Labs.,Inc., Chicago, Ill.
Matthiesen,P.,Southwestern Bell Tel. Co.,Oklahoma City, Okla.
McClure,R.F.,Maine Pub.Serv.Co.,Presque Isle
McElmurry, C.A., Genl. Elect. Co., Schenectady, N.Y.
McFadden,C.E.,Genl. Elect. Co.,Phila.,Pa.
McGonegle,R.J.,Lapeer,Mich.
McIntosh,R.B.,Elect. Controller & Mfg. Co., Cleveland,Ohio
McKeever,J.L.,Can.Genl. Elect. Co.,Ltd.,Peterboro, Ont.,Can.
McLeon,W.J.,Univ. of Calif.,Berkeley,Calif.
McLoughlin,J.E.,A.C.Gilbert Co.,New Haven, Conn.
McNair,I.M.,Newport News High School, Newport News, Va.
Meyer,F.J.,Old Appleton,Mo.
Meyer,G.H.,City of Los Angeles, Calif.
Meyers,G.J.,Jr.,Genl. Elect. Co.,Lynn, Mass.
Michael,P.O.,Assoc. Elect. Labs., Inc.,Chicago, Ill.
Middleton,J.E.,Stone & Webster Engg. Corp., Pottsville, Pa.
Miller,G.W.,Box 25,Hagerman,Idaho
Miller,H.G.,Bell Tel. Co. of Pa.,Pittsburgh,Pa.
Miller,R.A.,East Side High School, Newark,N.J.
Montgomery,G.D.,Am. Tel. & Tel. Co.,Denver, Colo.
Moore,W.E.,Am. Tel. & Tel. Co.,Erie, Pa.
Morton,G.V.,Jr.,Brooklyn Edison Co.,Brooklyn, N.Y.
Mullen,F.J.,3210 Bainbridge Ave.,Bronx, New York,N.Y.
Musgrove, C.C., Texas Creosoting Co., Dallas, Tex.
Nance,H.C.S.,Sch.of Engg.,Milwaukee,Wis.
Nartker,L.J.,Delco Products Co.,Dayton,Ohio
Nelson,J.M.,Bell Tel. Labs.,N.Y.C.
Nelson,L.N.,Genl. Elect. Co., Schenectady, N.Y.
Nichols,J.H.,Phoenix Utility Co.,Allentown, Pa.
Nissenson,P.S.,Northern States Pwr. Co.,St. Paul, Minn.
Oewel,J.A.G.,Pennsylvania Pr. & Lt. Co., Hazleton
O'Hara,E.G.,Sch. of Engg. of Milwaukee, Wis.
Painter,B.R.,Carnegie Steel Co.,Mingo Junction, Ohio
Palmrose,E.W.,Southern Pacific Golden Gate Ferries, Ltd.,San Francisco, Calif.
Pawlak,F.J.,Minnesota Pr. & Lt. Co.,Duluth, Minn.
Pease,D.S.,W.A.Pease,Chamberlain, So.Dak.
Pemberton,E.H.,Genl. Elect. Co.,Schenectady, N.Y.
Pennington,D.J.,Union Elect. Lt. & Pwr. Co., St. Louis, Mo.
Pentz,E.W.,Buffalo Genl. Elect. Co., N.Y.
Petit,A.M.H.,Marquette Univ.,Milwaukee,Wis.
Phillips,A.F.,Duquesne Light Co.,Pittsburgh, Pa.
Phillips,R.M.,Curtis Publishing Co.,N.Y.C.
Pickett,G.E.,Carolina Pwr. & Lt. Co., Raleigh, N.C.
Pleasants,J.G.,Calif. Inst. of Tech., Pasadena
Putnam,J.F.,United Elect. Lt. Co., Springfield, Mass.
Quigley,G.L.,Bell Tel. Labs.,N.Y.C.
Ramaley,E.J.,972 Pleasant St.,Boulder, Colo.
Raynor,W.R., N.Y. Edison Co., N.Y.C.
Reder,R.A.,New York & Queens Elec. Lt. & Pr. Co., Flushing, N.Y.
Reuter,H.H.,Pub. Serv. Elec. & Gas Co.,Irvington, N.J.
Roberts,E.R.,160 Schuylkill Ave.,Shenandoah, Pa.
Rosenberg,A.,City College of N.Y., N.Y.C.
Ross,G.A., Arizona State Teachers College, Tempe
Rossow,P.G.,Herreid,So.Dak.
Roswell,K.E.,Box 203,Devon, Conn.
Rudelius,C.E.,Northern Indiana Pub. Serv. Co., Hammond
Rulison,F.W. (Member) Northwestern Bell Tel. Co.,Des Moines, Iowa
Russell,L.W.,1473 N. Lake Ave.,Pasadena,Calif.
Russell,O.S.,Hydro-Elect. Pr. Comm. of Ont. Hamilton,Can.
Salo,E.A.,United Elect. Lt. & Pr. Co., N.Y.C.
Sands,P.J.,State of New York,Albany
Schierland,R.F.,Columbia Engg. & Mgt. Corp., Cincinnati, Ohio
Schmitt,H.M.,Brown Instrument Co., Phila.,Pa.
Schneider,F.W.,Am. Tel. & Tel. Co., Wheeling, W. Va.
Schofield,W.R.,(Fellow) Leeds & Northrup Co., Phila.,Pa.
Schroeder,H.H.,Ohio Bell Tel. Co.,Akron,Ohio
Schullerts,F.B.,Pacific Gas & Elect. Co.,Oakland,Calif.
Schumacher,L.R.,Hanson County Telephone Co., Alexandria, So. Dak.
Shaw,W.L.,Utah Lt. & Pwr. Co.,Salt Lake City, Utah
Shepard,R.K.,Western Elec. Co.,Kearny, N.J.
Sherard,G.L.,Am. Tel. & Tel. Co.,Denver, Colo.
Siegfried,V.,Stanford Univ.,Stanford Univ.,Calif.
Smith,C.E.,Ohio State Univ.,Columbus
Smith,D.H.,St. Elmo, Ill.
Smith,G.N.,Prod. Mach. Co.,Greenfield, Mass.
Smith,R.W.,Gen. Elec. Co.,Schenectady, N.Y.
Snyder,W.C.,Gen. Elec. Co.,Schenectady, N.Y.
Spence,W.D.,Std. Oil Co. of N.J.,Raleigh, N.C.
Spring,G.L.,Inland Steel Co.,Indiana Harbor, Ind.
Stanford,K.J.(Fellow)K.J.Stanford,N.Y.C.
Stier,H.E.,Western Elec. Co.,Inc.,Chicago, Ill.
Straley,M.R.,Soldier, Pa.
Street,W.E.,Texas Technol. College, Lubbock
Stuart,R.F.,Pacific Gas & Elec. Co.,Oakland
Stuehler,C.M.,United Engs. & Constrs. Inc., Newark, N.J.
Taylor,J.L.,11,261 S. Laflin St.,Chicago, Ill.
Thornton,R.E.,(Member)Oklahoma Gas & Elec. Co.,Sapulpa, Okla.
Timm,C.R.,343 Lansdowne Ave.,Westmount, Que.,Can.
Triplett,R.,Stanford Univ.,Stanford University, Calif.
Urban,C.,I. R. Nelson Co.,Newark, N. J.
Van Wormer,F.C.,Genl. Elec. Co.,Schenectady, N.Y.
Vessels,J.M.,Bell Tel. Co. of Pa.,Phila.,Pa.
Villegas,L.P.,924 Market St.,Tacoma, Wash.
Wagner,H.F.,Double Rainbow Mine, Deadwood, So. Dak.
Wagner,J.C.,SafeHarborWtr.Pr.Corp.,Marietta, Pa.
Weiner,I.,New England Adv. Co.,New Haven, Conn.
Weiss,E.H.,Lehigh Univ.,Bethlehem, Pa.
Welchans,C.A.,Vega Labs.,Inc.,New Rochelle, N.Y
Wenner,C.P., J.R. Kearney Corp., Cleveland, Ohio
Weston,I.E.,Westinghouse Elec. & Mfg. Co.,E. Pittsburgh, Pa.
Wey,R.C.,Ohio Power Co.,Canton, Ohio
Wheeler,S.M., (Member) Ohio Edison Co., Youngstown, Ohio
Wherry,W.J.,Pennsylvania RR.,Altoona, Pa.
White,D.C.,Am. Tel. & Tel. Co.,Ewart, Iowa
White,I.M.,Univ. of Calif.,Oakland
Wigley,J.L.,709 Woodland St.,Trenton, N.J.
Wiinikka,A.O.,29 Nutting St.,Fitchburg, Mass.
Will,A.J.,Northwestern Bell Tel. Co.,Omaha, Nebr.
Willis,B.D.,(Member) Asso. Elec. Labs., Inc., Chicago, Ill.
Willson,E.A.,Northern States Pwr. Co.,Minneapolis, Minn.
Wing,A.K.,Jr.,Kolster Radio Corp.,Newark,N.J
Wing,G.B., U.S. Coast & Geodetic Survey, Washington, D.C.
Winter,J.E.,Monongahela West Penn. Pub. Serv. Co.,Fairmont, W.Va.
Youngken,H.C.,732 Hawthorne Rd.,Bethlehem, Pa.
Zimmerman,S.W.,Genl.Elec.Co.,Pittsfield,Mass.

256 Domestic

Foreign

Chamberlain,O.E.,P.W.D. Substation, Penrose, N.Z.
George,C.F.,Syrian Church Rd.,Trichur,Cochin State, So. India
McLay,F.S.,Shanghai Power Co.,Shanghai, China
Mikaelian,A.H.,"His Master's Voice,"Istanbul, Turkey
Monsulas,K.J.,Monks & Ulen Co.,Serres, Greece
Riyat,M.C.,(Member) P. O. Box 892, Bombay, India
Shimogaichi,S.,Bur. of Electricity, Ministry of Communications, Tokyo, Japan

7 Foreign

January 1932

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□ 32-8	D. C. Prince	The Theory of Oil Blast Circuit Breakers
□ 32-9	R. M. Spurck	The Practical Application of the Oil Blast Principle of Circuit Interruption
□ 32-10	R. C. VanSickle and W. M. Leeds	Recent Developments in Arc Rupturing Devices
□ 32-11	T. E. Browne, Jr.	Extinction of A-C. Arcs in Turbulent Gases
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□ 32-26	S. B. Griscom, W. A. Lewis, and W. R. Ellis	Generalized Stability Solution for Metropolitan Type Systems
□ 32-27	A. G. Conrad and R. G. Warner	An Induction Motor with Paralleled Rotor and Stator
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□ 31-77	B. M. Smith and C. Concordia	Core Loss Measurements at High Flux Densities
□ 31-117	D. C. Jackson, Jr	Application of the Cooperative Method of Instruction to Engineering Schools and Polytechnic Institutes

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No. 2—Middle Eastern	W. B. Kouwenhoven, Johns Hopkins University, Baltimore, Md.	G. S. Diehl, Pennsylvania Water & Power Co., 1611 Lexington Building, Baltimore, Md.
No. 3—New York City	H. P. Charlesworth, 463 West St., New York, N. Y.	C. R. Jones, Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.
No. 4—Southern	W. E. Freeman, University of Kentucky, Lexington, Ky.	E. A. Bureau, University of Kentucky, Lexington, Ky.
No. 5—Great Lakes	T. N. Lacy, Mich. Bell Tel. Co., 1365 Cass Ave., Detroit, Mich.	A. G. Dewars, No. States Pr. Co., 15 S. 15th St., Minneapolis, Minn.
No. 6—North Central	P. H. Patton, Northwestern Bell Tel. Co., Telephone Building, Omaha, Neb.	M. S. Coover, University of Colorado, Boulder, Colo.
No. 7—South West	G. C. Shaad, University of Kansas, Lawrence, Kans.	R. W. Warner, University of Kansas, Lawrence, Kans.
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Name	District	Chairman	Secretary	Secretary's Address
Akron	2	R. R. Krammes	R. A. Hudson	Goodyear Zeppelin Corp., Akron, Ohio
Atlanta	4	A. G. Stanford	J. H. Persons	General Electric Co., Atlanta, Ga.
Baltimore	2	K. A. Hawley	J. Wells	Western Electric Co., Baltimore, Md.
Birmingham	4		O. E. Charlton	Allied Engineers, Inc., Birmingham, Ala.
Boston	1	C. A. Corney	G. J. Crowdes	Simplex Wire & Cable Co., Cambridge, Mass.
Chicago	5	F. R. Innes	E. C. Williams	20 North Wacker Drive, Chicago, Ill.

Local Sections of the Institute—Continued

Name	District	Chairman	Secretary	Secretary's Address
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Cleveland	2	G. A. Kositzky	F. E. Snell	Cleveland Railway Co., Cleveland, Ohio
Columbus	2	W. L. Everitt	Roy Mallory	Ohio Bell Tel. Co., Columbus, Ohio
Connecticut	1	R. G. Warner	W. B. Hall	Yale University, New Haven, Conn.
Dallas	7	Gibbs A. Dyer	S. M. Sharp	1100 Allen Bldg., Dallas, Tex.
Denver	6	R. E. Nyswander	N. R. Love	807 Tramway Bldg., Denver, Colo.
Detroit-Ann Arbor	5	J. J. Shoemaker	O. E. Hauser	Detroit Edison Co., Detroit, Mich.
Erie	2	P. R. Urich	C. V. Roberts	Erie Lighting Co., 21-23 West 10th St., Erie, Pa.
Florida	4	Joseph Weil	R. P. Smith	P. O. Box 2574, Jacksonville, Fla.
Fort Wayne	5	E. J. Schaefer	C. M. Summers	General Elec. Co., Fort Wayne, Ind.
Houston	7	E. M. Wise	J. S. Waters	Rice Institute, Houston, Texas
Indianapolis-Laf	5	E. L. Carter	E. G. Thoms	Indiana Bell Tel. Co., Indianapolis, Ind.
Iowa	5	H. B. Hoffhaus	Leon F. Wood	Telephone Bldg., 9th & High Sts., Des Moines, Iowa
Ithaca	1	W. E. Meserve	B. K. Northrop	Cornell Univ., Ithaca, N. Y.
Kansas City	7	George Fiske	R. M. Ryan	General Electric Co., Kansas City, Mo.
Lehigh Valley	2	Morland King	J. H. Diefenderfer	Penna. Pr. & Lt. Co., Hazleton, Pa.
Los Angeles	8	P. S. Biegler	F. E. Dellinger	Los Angeles Gas & Elec. Corp., Los Angeles, Calif.
Louisville	4	P. P. Ash	C. M. Ewing	Louisville Gas & Elec. Co., Louisville, Ky.
Lynn	1	J. A. Cook	G. R. Sturtevant	General Electric Co., West Lynn, Mass.
Madison	5	N. H. Blume	G. F. Tracy	University of Wisconsin, Madison, Wis.
Memphis	4	W. A. Gentry	F. L. Christenbury	Memphis Power & Light Co., Memphis, Tenn.
Mexico	3	E. F. Lopez	L. Castro, Jr	Dept. Elect. y Teleg., Ferrocarriles Nacionales de Mex., Mexico, D.F.
Milwaukee	5	C. H. Krueger	E. U. Lassen	Cutler Hammer, Inc., Milwaukee, Wis.
Minnesota	5	Oscar Gaarden	E. H. Hagensick	The Pyle-National Co., St. Paul, Minn.
Montana	9	J. A. Thaler	H. Dale Cline	312 So. 6th Ave., Bozeman, Mont.
Nebraska	6	A. L. Turner	C. Talsma	610 Electric Building, Omaha, Nebraska
New York	3	O. H. Caldwell	H. C. Dean	N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
Niagara Frontier	1	R. W. Graham	G. W. Eighmy	General Electric Co., 1100 Electric Bldg., Buffalo, N. Y.
North Carolina	4	J. E. Lear	R. F. Stainback	Box 1029, Chapel Hill, N. C.
Oklahoma City	7	C. T. Almquist	C. E. Bathe	Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Philadelphia	2	C. N. Johnson	J. L. MacBurney	Elec. Storage Battery Co., Philadelphia, Pa.
Pittsburgh	2	F. A. Conner	T. Spooner	Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Pittsfield	1	F. R. Finch	K. R. Van Tassel	General Electric Co., Pittsfield, Mass.
Portland, Ore	9	R. J. Davidson	F. M. Lewis	Northwestern Electric Co., Public Serv. Bldg., Portland, Ore.
Providence	1	W. S. Maddocks	O. W. Briden	Blackstone Valley Gas & Elec. Co., Pawtucket, R. I.
Rochester	1	F. C. Young	E. K. Huntington	Rochester Gas & Elec. Corp., Rochester, N. Y.
St. Louis	7	C. H. Kraft	C. H. Lankford	Century Electric Co., 1806 Pine St., St. Louis, Mo.
San Antonio	7	J. E. Woods	D. E. Woods	P. O. Box 1105, San Antonio, Texas
San Francisco	8	E. A. Crellin	W. C. Smith	872 Russ Bldg., San Francisco, Calif.
Saskatchewan	10	N. W. Dubois	A. B. Coward	Light & Power Dept., Regina, Sask., Can.
Schenectady	1	R. A. Beekman	E. P. Nelson	General Electric Co., Schenectady, N. Y.
Seattle	9	M. T. Crawford	C. B. Carpenter	836 Dexter Horton Bldg., Seattle, Wash.
Sharon	2	R. M. Field	A. M. Wiggins	Westinghouse E. & M. Co., Sharon, Pa.
Southern Virginia	4	J. H. Berry	E. L. Lockwood	Virginia Public Service Co., Newport News, Va.
Spokane	9	H. L. Vincent	W. M. Allen	Home Tel. & Tel. Co., Spokane, Wash.
Springfield, Mass	1	B. V. K. French	L. C. Packer	Westinghouse Elec. & Mfg. Co., Springfield, Mass.
Syracuse	1	C. W. Henderson	W. E. Mueller	Denison & Thompson, Syracuse, N. Y.
Toledo	2	J. A. Dinwiddie	Max Neuber	1257 Fernwood Ave., Toledo, Ohio
Toronto	10	T. W. Eadie	G. D. Floyd	Hydro Elec. Pr. Comm., 190 Univ. Ave., Toronto, Ont.
Urbana	5	E. H. Waldo	E. A. Reid	University of Illinois, Urbana, Ill.
Utah	9	Paul Ransom	A. L. Taylor	Univ. of Utah, Salt Lake City, Utah
Vancouver	10	G. R. Wright	C. Arnott	B. C. Elec. Railway Co., Ltd., Vancouver, B. C., Canada
Washington	2	G. L. Weller	C. M. Brown	Westinghouse Elec. & Mfg. Co., Washington, D. C.
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Total 60				

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Alabama, Univ. of	University, Ala	4	Robert Lake	W. R. Purcell	F. R. Maxwell, Jr.
Arizona, Univ. of	Tucson, Ariz	8	P. F. Hawley	T. S. Henderson	J. C. Clark
Arkansas, Univ. of	Fayetteville, Ark	7	H. D. Albrecht	R. Vining	W. B. Stelzner
Armour Inst. of Tech	Chicago, Ill	5	W. J. Jost	R. H. Frye	E. H. Freeman
British Columbia, Univ. of	Vancouver, B. C	10	D. S. Smith	H. M. Van Allen	E. G. Cullwick
Brooklyn, Poly. Inst. of	Brooklyn, N. Y	3	F. Anderson	I. Andreasen	H. B. Hanstein
Bucknell Univ	Lewisburg, Pa	2	Walter E. Hall	J. A. Everitt	G. A. Irland
Calif. Inst. of Tech	Pasadena, Calif	8	P. B. Lyons	R. W. St. Clair	R. W. Sorensen
Calif., Univ. of	Berkeley, Calif	8	John J. Cassidy	Sherroll L. Bettis	L. E. Reukema
Carnegie Inst. of Tech	Pittsburgh, Pa	2	W. B. Wigton	F. A. Lennberg	George Porter
Case Sch. of Ap. Science	Cleveland, Ohio	2	W. J. Lattin	K. R. Spangenberg	H. B. Dates
Catholic Univ. of America	Washington, D. C	2	Ralph Brady	R. F. Bourne	T. J. MacKavanagh
Cincinnati, Univ. of	Cincinnati, Ohio	2	W. Kock	C. J. C. Schmidt	W. C. Osterbrock
Clarkson College of Tech	Potsdam, N. Y	1	C. O. McNairn	J. H. O'Rourke	A. R. Powers
Clemson Agri. College	Clemson College, S. C	4	H. S. Montgomery	C. A. Farish	S. R. Rhodes
Colorado State Agri. College	Ft. Collins, Colo	6	Leroy Sweet	D. Pinkerton	F. L. Poole

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Cornell University	Ithaca, N. Y	1	R. A. Smith	W. S. Bachman	E. M. Strong
Denver, Univ. of	Denver, Colo	6	L. C. Trussler	Irwin Olcott	R. E. Nyswander
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Drexel Inst	Philadelphia, Pa	2	G. Koster	G. Mitz	E. O. Lange
Duke Univ	Durham, N. C	4	S. G. Flack	J. A. Womack	W. J. Seeley
Florida, Univ. of	Gainesville, Fla	4	R. E. Walker	L. P. Barnett	Joseph Weil
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Harvard Univ	Cambridge, Mass	1	E. A. Walker	C. N. Mason	C. L. Dawes
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Illinois, Univ. of	Urbana, Ill	5	B. Burgoon	D. L. Pettit	C. E. Skroder
Iowa State College	Ames, Iowa	5	Edwin K. Rohr	Alfred F. Zissler	F. E. Johnson
Iowa, State Univ. of	Iowa City, Iowa	5	David Marchant	Albert Behnke	E. B. Kurtz
Kansas State College	Manhattan, Kansas	7	G. E. Cain	D. E. West	R. G. Kloeffler
Kansas, Univ. of	Lawrence, Kansas	7	Edward Fisher	Jack Brous	D. C. Jackson, Jr.
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Lafayette College	Easton, Pa	2	Henry H. Jones	G. D. Hegeman, Jr	Lawrence Conover
Lehigh Univ	Bethlehem. Pa	2	L. F. Underwood	C. W. Banks	N. S. Hibshman
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Louisville, Univ. of	Louisville, Ky	4	P. A. Frank	H. K. Friedman	S. T. Fife
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North Carolina, Univ. of	Chapel Hill, N. C	4	D. J. Thurston, Jr	Sam Barham	J. E. Lear
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North Dakota, Univ. of	Grand Forks, N. D	6	B. J. Shields	Mark Scarff	H. F. Rice
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Ohio Univ	Athens, Ohio	2	George Wyckoff	C. C. Colombo	A. A. Atkinson
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Oklahoma, Univ. of	Norman, Okla	7	C. C. Ludwick	J. Strossberger	F. G. Tappan
Oregon State College	Corvallis, Ore	9	Dale Hansen	George Howie	F. O. McMillan
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Pennsylvania, Univ. of	Philadelphia, Pa	2	C. N. Maxfield	H. D. Sarkis	C. D. Fawcett
Pittsburgh, Univ. of	Pittsburgh, Pa	2	R. A. Hartley	J. W. Stirling, Jr	H. E. Dyche
Pratt Inst	Brooklyn, N. Y	3	Wm. H. Sutton	R. L. Bishop	C. C. Carr
Princeton Univ	Princeton, N. J	2	F. Siedler	J. H. Burnett	Malcolm MacLaren
Purdue Univ	Lafayette, Ind	5	P. O. Peterson	E. M. Sharer	A. N. Topping
Rensselaer Poly. Inst	Troy, N. Y	1	J. J. Lewis	H. A. Schlieder	F. M. Sebast
Rhode Island State College	Kingston, R. I	1	L. C. Breault	L. E. Crandall	Wm. Anderson
Rice Inst	Houston, Texas	7	M. E. Kattmann	E. A. Turner, Jr	J. S. Waters
Rose Poly. Inst	Terre Haute, Ind	5	J. Montgomery	Paul Froeb	C. C. Knipmeyer
Rutgers Univ	New Brunswick, N. J	3	F. Fisher	L. V. Banta	F. H. Pumphrey
Santa Clara, Univ. of	Santa Clara, Calif	8	L. W. Thorpe	T. Eberhard	E. F. Peterson
South Carolina, Univ. of	Columbia, S. C	4	L. E. Rankin	L. W. Dickinson	T. F. Ball
South Dakota State Sch. of Mines	Rapid City, S. D	6	A. M. Bjerke	C. C. Stephens	J. O. Kammerman
South Dakota, Univ. of	Vermillion, S. D	6	Myron Cole	C. Bauman	B. B. Brackett
Southern California, Univ. of	Los Angeles, Calif	8	M. C. Marshall	Louis Bayha	W. G. Angermann
Southern Methodist Univ	Dallas, Texas	7	J. V. Melton	R. L. Allen	H. F. Huffman
Stanford Univ	Stanford University, Calif	8	M. R. Jones, Jr	R. H. Born	W. Bryan Duncan
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Syracuse Univ	Syracuse, N. Y	1	M. A. Collins	M. E. Hogan, Jr	C. W. Henderson
Tennessee, Univ. of	Knoxville, Tenn	4	H. M. Patterson	C. T. Nunley	J. G. Tarboux
Texas Agri. & Mech. College	College Station, Texas	7	R. L. Suggs	C. H. Samuels	H. C. Dillingham
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Texas, Univ. of	Austin, Texas	7	T. E. Cole	D. Sussin	J. A. Correll
Utah, Univ. of	Salt Lake City, Utah	9	R. C. Hansen	W. S. Nishiyama	J. H. Hamilton
Vermont, Univ. of	Burlington, Vt	1	D. E. Child	R. A. Hyde	L. P. Dickinson
Virginia Military Inst	Lexington, Va	4	J. C. Shell	E. R. Trapnell	S. W. Anderson
Virginia Poly. Inst	Blacksburg, Va	4	R. E. McDaniel	P. H. Cross	Claudius Lee

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Washington, State Col. of	Pullman, Wash	9	D. H. Olney	G. C. O'Brien	O. E. Osburn
Washington Univ	St. Louis, Mo	7	Don A. Fischer	E. A. Wolff	W. L. Upson
Washington, Univ. of	Seattle, Wash	9	Allen S. Koch	Donald A. Date	G. L. Hoard
West Virginia Univ	Morgantown, W. Va	2	A. W. Friend	Philip Skaff	A. H. Forman
Wisconsin, Univ. of	Madison, Wis	5	T. N. Racheff	O. F. Vea	C. M. Jansky
Worcester, Poly. Inst	Worcester, Mass	1	R. G. Driscoll	Wm. A. Ardito	C. D. Knight
Wyoming, Univ. of	Laramie, Wyo	6	Neil Sanders	Roy Perkins	G. H. Sechrist
Yale Univ	New Haven, Conn	1	L. B. Hansen	F. M. Wolff	W. B. Hall
Total 109					

Affiliated Student Society

Brown Engineering Society..........Brown Univ., Providence R. I.

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during November are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

KINEMATICS OF MACHINERY. By C. D. Albert and F. S. Rogers. N. Y., John Wiley & Sons, 1931. 527 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $4.50.——This textbook is based upon the course given to engineering students at Cornell University but contains advanced material, in addition to that included in most courses, upon velocity and acceleration vector diagrams, cams, and spur gears. The treatment is concise, yet thorough, and many problems are included.

PRINCIPLES OF DIRECT-CURRENT MACHINES. By A. S. Langsdorf. 4th ed., N. Y. & London, McGraw-Hill Book Co., 1931. 586 pp., illus., diagrs., charts, tables, 8 x 6 in., cloth, $4.50.——This well-known text aims to supply a reasonably complete treatment of the fundamental principles that underly the design and operation of all types of d-c. machinery. This edition has been extensively rewritten, and new material has been added to bring it abreast of modern practise.

RADIO FREQUENCY ELECTRICAL MEASUREMENTS. By Hugh A. Brown. N. Y. & London, McGraw-Hill Book Co., 1931. 386 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $4.00.——The fundamentals of the standard methods are presented together with some of the recent advances in this field. The theory and principles are explained, the necessary steps in the laboratory procedure or manipulation are described, and the precision attainable, the precautions, and the general merits of the methods are discussed. The book is intended for students of radio communication and electrical measurements and also is designed to serve as a manual for the radio engineer.

THEORIE DER THERMISCHEN MESSGERATE DER ELEKTROTECHNIK, Grundlagen zu ihrer Berechnung. By J. Fischer. Stuttgart, Ferdinand Enke Verlag, 1931. 147 pp., diagrs., charts, tables, 10 x 7 in., paper, 13 RM.——Presents in systematic form the theoretical principles underlying hot-wire instruments, thermocouples, bolometers, and similar instruments, and summarizes the results of research upon the question of heat transfer. This knowledge is then used to discuss the theory of the various types of instruments. The book supplies the designer with the fundamental data that he needs.

PRINCIPLES OF ELECTRICAL ENGINEERING. By G. C. Blalock. N. Y., McGraw-Hill Book Co., 1931. 498 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $4.00.——A concise course in the fundamentals, with frequent references to practical applications. The text is intended primarily for students of civil, chemical, or mechanical engineering but may also be used by students of electrical engineering as an introduction to the subject.

RADIO RECEIVING TUBES. By J. A. Moyer and J. F. Wostrel. 2nd ed. N. Y., McGraw-Hill Book Co., 1931. 323 pp., illus., diagrs., charts, tables, 8 x 5 in., cloth, $2.50. ——The essential principles underlying the operation of vacuum tubes are explained in simple, nontechnical fashion in this book, which will meet the needs of the average student of radio communication. The construction, action, reactivation and testing of vacuum tubes are described, and their uses as detectors, amplifiers and oscillation generators explained. A chapter is devoted to specifications, and another to the applications of vacuum tubes to other industrial uses than radio transmission and reception.

SCIENCE IN ACTION. By E. R. Weidlein and W. A. Hamor. N. Y., McGraw-Hill Book Co., 1931. 310 pp., illus., tables, 9 x 6 in., cloth, $3.00.——This book gives a readable account of the methods by which scientific investigation has been applied to the problems of manufacturing, and of what has been accomplished by it. The history of industrial research is outlined, and some major achievements in promoting human welfare, in creating new industries, in preventing waste, and in improving social conditions are set forth. Suggestions for the organization of research work and the selection of workers are given.

A.S.T.M. TENTATIVE STANDARDS 1931. Philadelphia, Am. Soc. for Testing Mtl. 1008 p., 9x6 in., cloth, $8; paper, $7.——Tentative specifications, methods of test, and recommended practises which had been proposed to the association, but had not been formally adopted in September, 1931. 180 standards are given, 42 of which appear for the first time.

CONVERSION EQUIVALENTS IN INTERNATIONAL TRADE. By S. Naft. Philadelphia, Comm'l Museum, 1931. 357 p., 9x6 in., cloth, $5.——An unusually comprehensive collection of weights and measures. Factors and tables for converting the units of all countries are given in more than usual detail; tabulated alphabetically and geographically, as well as by systems. Attention is paid to compound conversions and to special measures used in engineering, commerce and various industries.

DIESEL REFERENCE GUIDE. By J. Rosbloom. Jersey City, N. J., Industrial Institute, Inc., 1931. 292 p., 10x8 in., cloth, $10.——Intended as a reference work for diesel engine owners, manufacturers and operators; brings together in convenient form such practical information as: theory and construction of the engines, their installation and management, accessories, fuels, repairing, descriptions of locomotive, airplane, and automobile engines. Diesel engine installations in America are listed.

ECONOMIC CONTROL OF QUALITY OF MANUFACTURED PRODUCT. By W. A. Shewhart. N. Y., D. Van Nostrand Co., 1931. 501 p., 9x6 in., cloth, $6.50.——An important work upon the use of statistical methods in the study of the problem of controlling the quality of manufactured articles. Using as an illustration the experience of the Bell Telephone Laboratories in developing the most efficient ways of applying these methods to the problems that arise in manufacturing, he explains clearly the mathematical and statistical principles that are involved, and shows how they are applied to actual problems.

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Selected Items From Current Literature

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns. All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page, or make translations of foreign articles at cost.

CABLES

Rubber Insulated. New Control Cables Have Improved Characteristics, H.M.Friend. *Power*, v 74, Nov 10, '31, p 666-9. Developments made in insulated wire and cable based on recent discoveries by rubber chemists and physicists and experimental research work of cable manufacturers in applying these discoveries; results of tests on rubber insulated cable.

Telephone. Placing of Aerial Cables by Suspension, R.Blain. *Telephone Engr.*, v 35, Oct '31, p 25-7. Importance of placing messenger at proper tension in aerial cable construction is explained; construction and use of tension indicator.

Underground—Manholes. Steel Forms for Concrete Manholes Show Economies, A.J.Batchelor. *Elec. World*, v 98, Oct 31, '31, p 777. $27.10 saving per job on labor alone is realized by Toledo Edison Co. through use of steel forms for building concrete underground system manholes; in the year since these forms were adopted company has used them eight times.

CIRCUIT BREAKERS

Oil. The Impulse High-speed Circuit Breaker, W.K.Rankin. *Gen. Elec. Rev.*, v 34, Oct '31, p 553-8. Initially developed for 25-cycle railway use; serviceable also for 60-cycle distribution; design based on new theory of current interruption; arc-quenching oil-blast produced mechanically; description of operation of mechanism and electrical performance.

CLOCKS

Electric. Electric Clocks, S.F.Philpott. *Elec. Rev.*, v 109, Oct 23, '31, p 626-7. Consideration of relative advantages of various types available.

CRANES

Electric. New Type Crane and Hoist, G.A. Caldwell. *Elec. World*, v 98, Oct 17, '31, p 692-5. Motor-generator set used as exciter for main a-c. crane or hoist motor to give dynamic control in lowering operations; principles used and description of application; practise illustrated on Brooklyn installation; speed-torque curves.

DUST PRECIPITATION

Electric. Selecting Equipment for Electrostatic Precipitation, R.H.Kaufmann. *Chem. and Met. Eng.*, v 38, Oct '31, p 570-2. Development of applications of Cottrell process; precipitation treater for recovery of sulphuric-acid mist; how high-voltage d-c. supply for treater operation can be obtained; removal of tar and residues from gases in precipitation treater.

DYNAMOMETER

Electric. Electric Dynamometers for Production Testing, F.W.Highfield. *Machy.*, v 39, Oct 1, '31, p 12-7. Operating principles and appl. with particular regard to testing of internal combustion engines. Before Instn. Production Engrs.

ELECTRIC DRIVE

Individual Drives Simplify Roll-Table Operation, W.B.Snyder. *Elec. World*, v 98, Oct. 10, '31, p 650-2. Conveyor tables with motor on each roll have had their greatest development and application in steel industry; but reduced maintenance, ease of control, and quiet operation should fit it into any industry where materials of suitable length are handled in processes of manufacture.

Industrial Plants. Electric Drive in Factories, W.P.Conly. *Elec. Rev.*, v 109, Oct 9, '31, p 527-8. Comparison with crude-oil engine; some data regarding consumption of electricity per hp. installed in different trades; results of analysis for various types of plants given in tables.

Pumps. Control of Synchronous Motor Pump Drives, R.C.Allen. *Maintenance Eng.*, v 89, Sept '31, p 462-5. Factors to be considered in appl. of synchronous motor to pump drive; control equipment; advantages of increased efficiency, and better power factor weighed against complexity of operation.

ELECTRIC MACHINERY

Testing. Losses in D-C. Machines from No-Load Tests, R.G.Isaacs. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1303-8. Determination of rotational losses of dynamos and motors that occur on load, by means of no-load test which allows for increase of iron losses due to load; theory of test and method of carrying it out; typical results show probable accuracy of method.

ELECTRIC MEASURING

Instruments. Electroscope Capacity Balance, W.C.Bayliss. *Australasian Elec Times*, v 10, Sept 28, '31, p 368-70. Apparatus developed by E.B.Brown exhibited at Melbourne Univ. Eng. School enables determination to be carried out very much more rapidly than, and quite as accurately as, usual methods.

ELECTROMAGNETS

Design and Construction of an Electromagnet for Investigation, E.J.Shaw. *Rev. Sci. Instruments*, v 2, Oct '31, p 611-7. Familiar du Bois type of magnet was not particularly suited for number of investigations of magnetic properties of atoms and molecules performed in laboratory of Univ. of Ill.; special type of electromagnet designed shows four outstanding features over type mentioned.

ELEVATORS

Control. Pliotron Tubes Level Elevators in McGraw-Hill Building. *Power*, v 74, Nov 3, '31, p 632-5. In new 33-story McGraw-Hill Building are 9 passenger and 5 freight elevators equipped with Pliotron leveling devices; elementary connection diagram of Pliotron elevator control system.

Door Operation. How Hoistway Door Operation Affects Elevator Service, H.B.Cook. *Power*, v 74, Oct '31, p 608-9. Method for determining force necessary for opening and closing different types of elevator hoistway doors and what effect increasing time of operation has on door mechanism.

ENGINEERS

Employment. How Many Engineers Are Now Unemployed? H.M.Friend. *Power*, v 74, Oct 27, '31, p 600-4. Analysis of survey based on Engg. Societies Empl. Service and various state and government agencies; registrations and placements per 1,000 members of 1927 to 1931.

FEEDWATER

Treatment. Solubility of Calcium Salts in Boiler Water, F.G.Straub. *A.S.M.E.—Advance Paper* for mtg. Nov 30-Dec 4, '31, 6 p. Purpose of investigation to determine behavior at elevated temperatures of various chemical compounds found in boiler waters.

FURNACES

Arc. Twenty Year Advance in Electric Arc Furnaces, W.E.Moore. *Heat Treating and Forging*, v 17, Oct '31, p 982-7. Paper before Electrochem. Soc. previously indexed from their preprint, no 60-11 for mtg. Sept. 2-5, 1931.

Industrial. Industrial Gas and Electric Furnaces, E.Gossow. *Eng. Progress*, v 12, Oct '31, p 217-22. Operating characteristics and classification of industrial furnaces; furnace atmosphere; gas furnace, fuel gases, burners; examples of large industrial installations.

Melting. The Manufacture of Acid Electric Steel and Cast Iron, H.H.Walther. *Iron and Steel Engr.*, v 8, Oct '31, p 415-22. Practical features involved in successful economical operation of electric furnaces of 3-ton per hr. capacity, direct arc, 3-phase; electric furnace costs covering 4-week period.

GATES

Hydraulic Ellipsoid. Lightness and Low Costs Obtained by New Penstock Gate Design, A.J.Ackerman. *Eng. News-Rec.*, v 107, Oct 15, '31, p 600-4. Design and fabrication of ellipsoid, nearly all welded, emergency gate, 16 ft.in diam., for pressure tunnel at Calderwood dam in Tennessee; maximum head of 260 ft. was assumed; special tests of restrained plates.

HYDROELECTRIC

Power Irrigation. Hydro Power Provides Revenue for Irrigation Works, H.A.Brown. *Power*, v 74, Nov 10, '31, p 663-5. By combining power development with irrigation dams possible to pay project's construction costs from power sales.

INSULATING MATERIALS

Specifications. Methods of Test Relating to Electrical Insulating Materials. *A.S.T.M.—Report Committee* D-9, '31, 212 p. Compilation of standards and tentative standards, together with annual report of committee.

LAMPS

Arc. Construction and Operation of Capillary Mercury Arcs, R.H.Crist. *Optical Soc. America—Jl.*, v 21, Oct '31, p 690-7. Nature of problem and experimental development; nature of deposit; character of emission; curves.

Glow. A Cold-Cathode 110-Volt Gaseous Illuminant. *Electronics*, v 3, Oct '31, p 140-1. Two forms of Spanner Germer-Doring gaseous lamp adapted for operation in standard lamp socket for 110 volts a-c. or d-c.

LIGHTING

Airplane. Lights for Airplanes, R.W.Cost *Elec. Jl.*, v 28, Oct '31, p 573-5. Equipment and its installation; notes on incandescent lamps; navigation; instrument board lights; cabin lights; landing lights; lighting circuits.

Airport. The Detroit City Airport Anticipates Night Flying, H.K.Flint. *Elec. Jl.*, v 28, Oct '31, p 566-7. More than 50 floodlights, each producing beam intensity of about 10,000,000 candle-power, furnish illumination for night movements of airplanes at Detroit City Airport.

Fog. Transmission of Light Through Fog, F.C.Breckenridge. *Aircraft Eng.*, v 3, Oct '31, p 261-4. Attempt to correlate results of fog-chamber investigations by C.L.Utterback, S.H. Anderson, and H.G.Houghton, and with natural fog by E.Farrer, E.P.T.Tyndall, F.Benford, L.P.Granath and E.O.Hulburt; particle sizes; formation of haze particles. Before Int. Illum. Congress.

Houses. Your Lights at Home, M.A.Sheppard. *Elec. Jl.*, v 28, Oct '31, p 553-6. Rich market lies before electrical industry; best attack is probably encouraging those in industry to have their own homes adequately lighted; lights must be integral part of home furnishings rather than afterthought.

Street. Modern Street Lighting Practise, L.A.S.Woods. *Elec. Jl.*, v 28, Oct '31, p 557-9. Modern city plans its street lighting from investigation of requirements for each locality; outstanding examples of such comprehensive street-lighting plans are cities of Milwaukee and St. Louis. Before Int. Commission of Illum.

Street Cutouts. Series Street Lamp Has Inbuilt Cutout. *Elec. Jl.*, v 28, Oct '31, p 570. Novel idea of using one of best conductors, copper, for insulator is basis of new inbuilt cutout for series lamps; copper particles are covered with insulating film, which breaks down at lamp failure, allowing copper to fuse and reestablish circuit.

LOUD SPEAKERS

Diaphragms. Behaviour of Conical Diaphragms used in Acoustic Apparatus for Reproduction of Speech and Music, N.W.McLachlan and G.A.V.Sowter. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, v 12, Oct '31, p 771-815. Conical Diaphragms with free edge, with reinforced edge and with rubber surround; comparison of three preceding cases; modes of diaphragm corresponding to upper frequency resonances; influence of coil mass, etc.

Horns. Indoor Applications of Air-Column Horns, C.J.Brown. *Projection Eng.*, v 3, Oct '31, p 15-6. Type of horn to be used under given conditions is described and illustrated.

MAGNETISM

Temperature Variation of Intrinsic Magnetization and Associated Properties of Ferromagnetics, E.C.Stoner. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, v 12, Oct. '31, p 737-63. Relation of intrinsic magnetization to other properties of ferromagnetics is briefly discussed, and evidence for regarding ferromagnetism at ordinary temperatures as due to interchange interaction of electron spins is summarized. Bibliography.

New Theory of Magnetic Storms—I—Initial Phase, S.Chapman and V.C.A.Ferraro. *Terrestrial Magnetism and Atmospheric Electricity*, v 36, June '31, p 77-97 and Sept p 171-86. Motion of infinite plane-slab stream, cylindrical stream and neutral ionized system of any form in uniform magnetic field; internal steady motion of neutral ionized stream in non-uniform magnetic field; phenomena accompanying advance of solar ionized stream into earth's field.

MANHOLES

Standardization. Simplification and Standardization of Manhole Frames and Covers, L.B. Fish. *ASA Bul.*, Sept '31, p 26-8. Progress reports of sectional committee of ASA Telephone Group and A.S. of C.E.; types and sizes reduced; simplification of materials.

MANOMETERS

Vacuum Tube. Measuring One Trillionth of an Atmosphere, E. K. Jaycox. *Bell Lab. Rec.*, v 10, Oct '31, p 34-8. In making studies of phenomena requiring high degree of vacuum, it is important that physicists have knowledge of degree of pressure within apparatus; ionization manometer for accomplishing this was invented by O.E.Buckley in 1916; ionization manometer for this purpose of new design has been recently developed by H.W.Weinhart and author.

MICROPHONES

Moving Coil. A Moving Coil Microphone for High Quality Sound Reproduction, W.C.Jones and L.W.Giles. *Projection Eng.*, v 3, Oct '31, p 10-2. Microphone described is more efficient than conventional form of condenser microphone and its transmission characteristics are unaffected by changes in temperature, humidity and barometric pressure.

MOTORS

Commutator. Alternating-current Commutator Motors. *Engineering*, v 132, Oct 30, '31, p 559-60. 90-hp., 220-volt, 3-phase machine, built

by Holmes for abnormal range of 12.5 to 1, has speed range of from 375 to 30 r.p.m., with constant torque of 1,200 ft.-lb.

Design. Design of Electric Motors for Intermittent Service, C.Schiebeler. *Engineering*, v 132, Oct 30, '31, p 566-8. Study of conditions in motor when operating on short-interval intermittent service.

Induction. Induction Motors for Frequent Reversing, R.F.Emerson. *Power*, v 74, Nov 3, '31, p 637-8. Practical discussion of effects of motor-reversing operations; curves showing number of reversals possible with 50 deg. cent rise when using general-purpose squirrel-cage motor and motor with high-resistance rotor.

Railroad. Field Shunting and Modern Motor Design, L.B.Hewitt. *Elec. Ry., Bus and Tram Jl.*, v 64, Mar 13, '31, p 141-3. If interest in this direction can be stimulated one may have hope that manufacturers will produce suitable motors designed for far greater range of field control than any at present on market; economies to be obtained together with savings in weight, cost of resistances, and control equipment would be more than adequate compensation.

Single-Phase. Capacitor Single-Phase Motors, L.T.Campey. *Maintenance Eng.*, v 89, Sept '31, p 427-31. Review of theory and design, and general statement of applications, discussing advantages and limitations; motor operation curves and control.

Squirrel Cage. Some Features of the Polyphase Squirrel-Cage Induction Motor, F.Miller. *Gen. Elec. Rev.*, v 34, Oct '31, p 548-52. Mechanical construction; stator windings; final drying and insulating; electrical relationships; characteristics of motor with respect to rotor design; characteristic curves as samples of rotor punching are given.

NETWORKS

New System of Distribution. *Elec. News*, v 40, Nov 1, '31, p 35-7. Proposed type of general purpose system for moderately loaded areas that utilizes single conductor, shielded aerial cables, supported by messenger forming common neutral of 4,600/8,000Y volt circuit; details of system.

Design. A Proposed Type of General Purpose Distribution System for Moderately Loaded Areas, G.H.Underhill. *N.E.L.A.—Bul.*, v 18, Oct '31, p 669-77 and 693. Proposed system is advanced areas; it utilizing single conductor, shielded aerial cables, supported by messenger which forms common neutral of 4,600/8,000Y volt circuit. Paper won first award in James H. McGraw prize contest for 1931.

Frequency Operation. Changing a System Frequency—I, E.Smart. *Elec. Lt. and Pwr.*, v 9, Nov '31, p 26-8. Empire District Electric Co. of Joplin, Mo., completed 25-cycle to 60-cycle conversion project at cost of $2,000,000; project included replacement of original turbines and 25-cycle generators in Company's main hydroelectric plant on White River, with 60-cycle equipment having total capacity of 20,000 kw.; conversion of 66-kv. circuit and connections thereto to 60-cycle service.

OSCILLOGRAPHS

Cathode-Ray—Measurements. Phase Measurements with the Cathode Ray Oscillograph, L.A.Wood. *Rev. Sci. Instruments*, v 2, Oct '31, p 644-8. Theoretical mathematical analysis, pertaining to suitability for oscillograph for this type of measurements.

PHOTOELECTRIC CELLS

New Applications of Photo-Cells for Control of Handling Equipment, R.F.Yates. *Matls. Handling and Distribution*, v 6, Sept '31, p 45-6. Features of application of photo-cells for automatically controlling conveying equipment in filling of ore and grain bins.

Engineering Development of Photovoltaic Cells, C.G.Fink and D.K.Alpern. *Am. Electrochem. Soc.—Trans.*, v 58, '30, p 275-98. New photovoltaic cell, designed for industrial purposes, is described and some operating data and characteristic curves are presented, as introduction to general treatment of subject; cell contains lead anode and copper-oxide cathode.

Applications. Electronic Control of Machinery, R.F.Yates. *Iron Age*, v 128, Nov 5, '31, p 1170-2. Photoelectric tubes are designed for various specific operating conditions not admitting use of mechanical counters; thyratrons controlling comparatively large current without mechanical relays.

POTENTIOMETER RECORDERS

New Brown Potentiometer Recorder, T.R. Harrison. *Rev. Sci. Instruments*, v 2, Oct '31, p 618-25. Brown potentiometer recorder is illustrated and described in some detail; is suited to use as self-balancing wheatstone bridge, for resistance thermometry, and for many other uses.

POWER INDUSTRY

Accounting. Accounting Fundamentals Applied to Purchased and Generated Power, J.W. Romig. *Power*, v 74, Oct 27, '31, p 605-7. Separating fixed charges for economic comparisons; features of mixed-pressure unit; uses of variable and fixed costs.

Rate Making. How to Handle a Rate Case, C.B.Cooke,Jr. *N.E.L.A.—Bul.*, v 18, Oct '31, p 657-9. Cost-to-company is more practical and reliable index for permissible rates to large customers than value of service to them which is usually greater than can be obtained in rate.

PUBLIC ADDRESS SYSTEMS

Design and Assembly of Outdoor Public-Address Systems, G.S.Mitchell. *Projection Eng.*, v 3, July '31, p 14-6. Instructive details of unit assembly and placement for outdoor sound transmission.

High Power for the Public-Address System, C.H.W.Nason. *Projection Eng.*, v 3, Oct '31, p 14. Availability of type 556 mercury-vapor rectifier simplifies construction of outdoor sound system; installation for theater, auditorium or outdoor use, wherever high quality channel of power involved is desired, is shown schematically.

An Audio-Radio Distribution and Control Circuit, R.P.Glover. *Electronics*, v 3, Oct '31, p 155. In some instances it would be desirable to retain feature of selection and control over radio programs at individual receiving points and at same time afford advantages of centralized distribution of voice and records; schematic diagram of such installation is shown.

RADIO

Antennas. Development of Directive Transmitting Antennas by R.C.A. Communications, Inc., P.S.Carter, C.W.Hansell and N.E.Lindenblad. *I.R.E.—Proc.*, v 19, Oct '31, p 1773-1842. Various types of directive antennas are theoretically analyzed and their performances under practical conditions studied; effects of seasonal variations, heights above ground and polarization are considered; radiation properties of simple wires and radiation patterns of various combinations of wires are described in detail.

Antennas—Short Wave. Developments in Short-Wave Directive Antennas, E.Bruce. *Bell Syst. Tech. Jl.*, v 10, Oct '31, p 656-84. Previously indexed from *I.R.E.—Proc.*, Aug. 1931.

Circuits. Series Equivalent of a Resistance Paralleling a Tuned Circuit, C.H.W.Nason *Radio Eng.*, v 11, Oct '31, p 28. Simple mathematical analysis of determining effect of resistance and detector circuit.

Engineers. The Spokesman for the Radio Engineer, S.C.Hooper. *I.R.E.—Proc.*, v 19, Oct '31, p 1843-8. Radio today is compromise between engineers, department store managers, politicians, theater owners, and lawyers; had engineers proceeded properly in beginning they would have first reached accord among themselves as to what set-up should be; problem of getting Congress and executive branch to provide needed laws and regulations would have been very easy.

Interference. Radio Interference. *Elec. Mfg.*, v 8, July '31, p 31-2. Factors to consider when selecting motors; table shows part electric motors played in causing radio interference in 16 cities of less than 15,000 population.

Interference. High-Frequency Atmospheric Noise, R.K.Potter. *I.R.E.—Proc.*, v 19, Oct '31, p 1731-65. Method which has been employed in measurement of high frequency atmospheric noise is described; using this method measurements of noise over range from 5 to 20 megocycles made in different parts of U.S.A. and at different times of year, show distinct diurnal change in intensity similar to that for long-range high-frequency signal transmission.

Inverters. D-C. Inverter for Radio Receivers, W.R.G.Baker and J.I.Cornell. *Electronics*, v 3, Oct '31, p 152-4. Device for changing d-c. into a-c.; supplies a-c. from d-c. mains at required voltage and frequency and may be mounted in cabinet with receiver; development has been made possible through use of thyratron

Receiving Apparatus, Short-Wave. Factors in the Selection of the Proper Radio Power Transformer, J.A.Comstock. *Radio Eng.*, v 11, Oct '31, p 17-9. Transformer should meet tolerances set forth by radio engineer, and in most cases these are in neighborhood of plus and minus 3 per cent on filament windings and plus and minus 5 per cent on high voltage windings and be capable of withstanding dielectric tests specified by Underwriters' Laboratories, and application.

Telegraph. Application of Printing Telegraph to Long-Wave Radio Circuits, A.Bailey and T.A.McCann. *Bell Syst. Tech. Jl.*, v 10, Oct '31, p 601-15. Arrangements which have been used for start-stop printing telegraph operation over transatlantic long-wave radio channel.

Waves, Long—Measurement. Long-Wave Radio Receiving Measurements at the Bureau of Standards in 1930, L.W.Austin. *I.R.E.—Proc.*, v 19, Oct '31, p 1766-72. Tables of monthly average field intensities of various long-wave stations, and corresponding atmospheric disturbances measured in Washington in 1930.

Waves, Ultra-Short. The Attenuation of Ultra-Short Radio Waves Due to the Resistance of the Earth, R.L.Smith-Rose, and J.S.McPetrie *Phys. Soc.—Proc.*, v 43, Sept 1, '31, p 592-612. Investigation of attenuation of radio waves, of wavelengths between 5 and 10 meters, when transmitted directly along earth's surface; transmitters employed, one being fixed installation used with input power supply of order of 500 watts, other transportable set operated with input supply of about 50 watts obtained from batteries, are described.

RAILROADS

Controllers. New Cam Type Controller. *AEG Progress*, v 7, Sept-Oct '31, p 190-3. Features and characteristics of new AEG type, *i. e.*, contacts, contact fingers, arc-extinguishing devices, contact pressure and action, contact battens, cam drum, notched wheel, reversing and braking drums, design of housing, connections and mode of operation; 60,000 km. service within interval of two main inspections without overhaul of contacts cited.

Economics. Economics of Electric Railway Operation, J.R.Ong. *Elec. Traction*, v 27, Oct '31, p 498-9, see also *Elec. Ry. Jl.*, Oct '31, p. 570-1. Faster schedules of paramount importance; new equipment increases riding; reducing operating expenses; savings in bus operation; savings in reducing costs of accident. Before A.E.R.A.

Power Supply. Power Generation and Distribution Have Undergone Many Changes, C.R. Harte. *Elec. Ry. Jl.*, v 75, Sept 15, '31, p 542-5. Historical review of power plant design and electric power distribution for street railroads; details of specific installations.

Regenerative Control. Tramway Regeneration, G.H.Fletcher. *Elec. Ry., Bus and Tram Jl.*, v 65, Sept 18, '31, p 132-45. Manchester Tramway System and Tramways Department of Glasgow decided made trial with Parisian system; in both cases series-parallel scheme was selected; results obtained from Manchester experiment; brief description of car and its equipment. Before Manchester Mun. Tramways and Transport Assn.

Signals and Signaling. Chicago, St. Paul, Minneapolis and Omaha Eliminates Nearly 20,000 Train Stops Annually. *Ry. Signaling*, v 24, Oct '31, p 337-41. Grade crossing with Chicago, St. Paul, Minneapolis and Omaha, gauntlet drawbridge, and junction switches controlled by table interlocking machine; mechanical gate protection solves light-traffic crossing problem.

Signals and Signaling—Interlocking. C.B. and Q. Installs Electric Interlocking, W.F. Zane. *Ry. Signaling*, v 24, Oct '31, p 331-4. Plant first of six large signaling units in rearrangements of Galesburg, Ill., terminal facilities; schematic diagram showing general layout; track-and-signal plan of controlled territory; outside equipment; cable distribution.

Power Interlocking Eliminates Delays. *Ry. Signaling*, v 24, Oct '31, p 342-4. Reconstruction program involves installation of two electro-pneumatic plants on Norfolk and Western at Portsmouth, Ohio; track layout; a-c. operation and control in both plants.

Chicago and Illinois Midland Installs Electric Interlocking. *Ry. Signaling*, v 24, Oct '31, p 335-6, and 341. Crossing with Wabash protected by modern plant; highway crossing protection special features; track-and-signal plan of plant at Springfield, Ill.; interlocking machine; signals and switch machines; special crossing signs.

Remote Control for Interlocking Saves $6000 Annually. *Ry. Signaling*, v 24, Oct '31, p 345-6. 30-lever plant, including highway-crossing protection now handled by all-relay control with 7-lever centralized-type machine in station 1.2 mi. away; control machine; layout plan of remotely controlled plant; control circuit; yard indicator.

Signals and Signaling—Remote Control. The Operation of Long-Distance Points by Hand-Generated Power—I. *Ry. Engr.*, v 52, Oct '31, p 370-4. Outline of systems whereby long-distance low voltage point mechanism operates without batteries; arrangement of lines and signals, circuits for long-distance point operation Great Southern Railways, Ireland; past and present arrangement of lines and signals at Collooney.

Tracks. Advances in Electric Railway Track Construction Standards. *Can. Ry. and Mar. World*, Oct '31, p 653-4. Diagrams illustrating design and constructional features.

Train Control—Equipment. How to Use a Train Control Output Meter. *Ry. Elec. Engr.*, v 22, Oct '31, p 268-9. Periodic checking of loop and track phase circuits provides means for determining condition of train control equipment and lessens possibility of failure.

REACTORS

Control. Direct-Current Controlled Reactor, E.C.Wentz. *Elec. Jl.*, v 28, Oct '31, p 561-3. Long known as 3-legged reactor, apparatus is really analogous to 3-element amplifier tube and can be used as regenerative amplifier; it may also be used as relay, or as variable reactor; characteristic curves, practical uses and hook-ups.

RECTIFIERS

Series-parallel Type Static Converters—II, C.A.Sabbah. *Gen. Elec. Rev.*, v 34, Oct '31, p 580-9. Polyphase series-parallel or series polycyclic static converter is discussed; definition and description; calculation of circuit; voltage relations; interphase transformer voltage; general graphical method and circle diagram or polar coordinates; numerical examples of calculation of 3-phase circuit by analytical method.

Transformers. Method for Eliminating Pulsations in the Terminal Voltage of Mercury Arc

Rectifiers, K.Ohsumi. *Inst. Elec. Engrs. Japan —Jl.*, v 51, July '31, p 380-5; see also English Abstract, on p 61-3. For extinguishing all alternating components from output voltage of rectifiers, author devised single-phase 3-winding transformer which is described in detail.

REGULATORS

Induction. The Application of the Induction Voltage Regulator, W.E.M.Ayers. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1208-18 and (discussion) 1218. General application of induction regulators to feeder systems and distribution networks; problem of fully automatic control; application of regulator in system considered from its practical and economic aspects; financial aspect; twin polyphase induction regulators; special applications and connections.

RELAYS

Testing. Theory and Application of Relay Systems—Relay Testing and Maintenance—I, P.H.Robinson and I.T.Monseth. *Elec. Jl.*, v 28, Oct '31, p 581-4. Investigation of new relays; initial tests; testing induction-type relays; directional tests.

SUBSTATIONS

Work Designs. Tapping 110-Kv. Trunk Line to Serve Small Community. *Elec. World*, v 98, Oct 31, '31, p 776-7. Sevierville, 110/13.8-kv. substation of Tenn. Pub. Serv. Co., represents another effort on part of power companies to provide small community with good electrical service from high-voltage trunk line without unduly hazarding trunk-line service.

SYMBOLS

International Electrotechnical Commission. International Symbols—III; Graphical Symbols for Weak-Current Systems. *I. E. C.—Pub.* no. 42, '31. Symbols for practical purposes representing object in very reduced and simple form and making it possible to draw any diagram in minimum time while giving it all desired clearness and convenient size. (In French and English.)

Standardization. The A.I. & S.E.E. Suggestions to the Electrical Manufacturers in Connection with Standardized Symbols for Control Apparatus. *Iron and Steel Engr.*, v 8, Oct '31, p 438-9 and (discussion) 439-45. Tab. of suggestions.

TELEPHONE

Exchanges—Airships. Aerial P.B.X. on World's Largest Airship, A.Parlett, Jr. *Telephony*, v 101, Oct 31, '31, p 31-2. Description of telephone installation on U.S.S. Akron, world's largest airship recently built for U.S. Navy, comprised of specially constructed switchboard and 17 telephones.

Receivers—Moving Coil. Moving-Coil Telephone Receivers and Microphones, E.C. Wente and A.L.Thuras. *Bell Syst. Tech. Jl.*, v 10, Oct '31, p 565-76. Moving coil head receiver and microphone designed particularly for high quality transmission; instruments have substantially uniform response from 40-10,000 c.p.s.

Relays. Characteristics of Strowger Relays, K.W.Graybill. *Telephone Engr.*, v 35, Oct '31, p 30-1. Characteristics of various special types of relays in curves are given and explained.

Systems—Interconnection. Interconnection of Telephone Systems—Graded Multiples, R.I.Wilkinson. *Bell Syst. Tech. Jl.*, v 10, Oct '31, p 531-64. General problem of subscriber interconnection; economic and service factors in selection of trunking systems; characteristic manner in which telephone calls fall upon ordinary straight trunk groups; theoretical analysis of graded multiples from which are constructed curves for common probabilities of loss; comparison of theory and observation.

TELEVISION

Technical Problems in Connection with Television, C.O.Browne. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1232-8. Present day television is confronted with two main problems, that of transmitting signals which correspond to picture elements necessarily embracing large frequency band; second, that of providing sufficient illumination on receiver screen to enable audience to view received image simultaneously.

Apparatus. A Television Projector for Screen Pictures. *Projection Eng.*, v 3, July '31, p 13. Projector type televisor, designed by DeForest engineers, which throws television pictures received on screen so that they may be seen by small theater audience; extreme flexibility for television flying spot, is obtained.

Apparatus, Superheterodyne. Television Reception with the Superheterodyne, R.W. Tanner. *Radio Eng.*, v 11, Oct '31, p 23-5. Engineering details of design of superheterodyne receiver suitable for television.

Fidelity Charts. Measurement of Fidelity in Television Systems, A.F.Murray. *Electronics*, v 3, Oct '31, p 137-8. Reproduction of charts devised in R.C.A. Victor Research Laboratory for measuring fidelity and for comparison of shades.

THERMOCOUPLES

New Uses for the Thermocouple. *Projection Eng.*, v 3, Oct '31, p 13 and 16. New type of thermocouple potentiometer of General Electric Co. for accurate temperature measurements; principle overcomes need for standard cell, which requires frequent balancing to make certain that potentiometer current has not varied.

TRANSFORMERS

Recent Progress in Large Transformers, R.M. Charley. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1189-1207. General description of progress made in recent years and examples illustrating present stage of art; notes on problem of transport; comparison of 3-phase units with banks of single-phase units; shell-type vs. core-type transformers; core construction; cooling; "Intertaire" transformers; Buchholz protective device; interturn insulation; non-resonanting transformers, etc.

Connection. Calculation of Line-to-Line Ratios and Phase Angles of a Combination of Three Single-Phase Voltage Transformers Star-Connected on a Three-Phase System, The Star Point being Earthed, A.C.Crawley. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1293-4. Development of algebraic expressions for calculation of ratio and phase-angle errors from measured values.

Silica Gel Breathers. A Silica Gel Transformer Breather. *Engineer*, v 152, Oct 16, '31, p 418-9. Particulars of breather for transformers, designed to replace those employing calcium chloride; breather can be made for all capacities and can also be applied to joint boxes and oil transport and storage tanks.

TRANSMISSION LINES

Calculation. Symmetrical Components—IX, C.F.Wagner and R.D.Evans. *Elec. Jl.*, v 28, Oct '31, p 586-90. Discussion of phase sequence constants of transmission lines with ground wires; positive and negative sequence impedance; zero-sequence impedance; practical calculation of zero-sequence impedance; electrical characteristics of steel ground wires; copper-clad steel cables.

Failures. Interruptions to Lines Concentrated at Sunrise—Why? E.E.George and W.R. Brownlie. *Elec. World*, v 98, Oct 10, '31, p 658-61. Idea of relative importance of lightning and other causes may be had from record of 110 kv. and 154 kv. outages on Tenn. Elec. Pwr. Co.'s transmission system; 70 per cent of non-lightning outages fall in sunrise band; switching operations shifted away from sunrise period.

Rural—Costs. Rural Lines for $500 per Mile, M.T.Crawford. *Elec. World*, v 98, Oct 17, '31, p 690-1. Northwest Elec. Lt. and Pwr. Assn., surveyed practise of all member companies and prepared data on types of construction indicating present general practise; cost of special type of construction of Portland Gen. Elec. Co., adding 15 per cent overhead and reasonable amount of secondary circuit, transformers and meters will not much exceed $500 per mile.

VACUUM TUBES

Industrial Application. Electron tube in Machine Design, R.F.Yates. *Machy. (N.Y.)*, v 38, Oct '31, p 95-6. How vacuum tube, photoelectric cell, and grid-glow tube are being used by machine designers for grading, measuring and counting.

WATER HEATING

New Possibilities in Off-Peak Water Heating, *Elec. West*, v 67, Oct 1, '31, p 179-81. After study of some months' duration involving analysis of experience with high-voltage water heaters on meter rate and low-wattage heaters on flat rate, and experiments with various types of heaters, tanks and insulation, Puget Sound Pr. & Lt. Co., Seattle, has established new water heating rate offering low priced energy on off-peak hours for storage-type water heaters.

WELDING

Arc. Developments in Arc Welding as Applied to Oil Industry, J.C.Lincoln. *Oil Weekly*, v 63, Oct 16, '31, p 18-24. Application of shielded arc process to welding of pipe lines, oil tanks, vaporizer tubes and other fields and refinery equipment. Before Am. Petr. Inst.

Shielded Arc and the New Code, G.Raymond. *Welding Engr.*, v 16, Sept '31, p 42-4. Qualities of weld metal which are called for by revised A.S.M.E. boiler code; corrosion resistance of shielded arc weld demonstrated by deep etching test; tensile tests of shielded arc welds through which holes have been drilled; bend tests demonstrate ductility and toughness.

Bronze. Improved Product by the Use of Bronze Welding, H.F.Reinhard. *Am. Welding Soc.—Jl.*, v 10, Oct '31, p 5-8. Bronze welding as applied to light gage galvanized sheet steel and iron in fabrication of house lighting and cooking type acetylene generator; bronze welded seams 315 per cent stronger than soldered double-lock seams.

Locomotive Boilers. Welding Practise in Northern Pacific Boiler Shops. *Boiler Maker*, v 31, Oct '31, p 274-7. Details of welding equipment and practise.

Locomotive Fireboxes. Welding in the Locomotive Boiler, J.M.Vossler. *Welding*, v 2, Oct '31, p 679-81. Practise of Southern Pacific Lines, Houston, Tex.; joining sheets in locomotive firebox by electric arc process. (To be concluded.)

Machines, Spot. Heavy-Duty Spot-Welding Machine. *Engineering*, v 132, Oct 23, '31, p 539. Machine by British Insulated Cables, Ltd., is suitable for making welds up to ½ in. in diam. in two or more pieces of mild steel having total thickness up to ¾ in., and at speeds up to 600 welds per hr.; comprises 60-kw. single-phase, air-cooled transformer.

Machinery Bases. Reducing Weight and Production Costs, C.M.Taylor. *Welding Engr.*, v 16, Sept '31, p 58-60. How bending brake and electric arc work together to improve design of machine bases and cut cost of manufacture.

Machine Tool Manufacture. Machine Tool Frames Produced by Welding, J. R. Weaver. *Machy. (N. Y.)*, v 38, Nov '31, p 171-3. Principles governing construction of machine tool frames and bases by arc welding illustrated by examples.

Pipe. Welding of Copper and Brass Pipe, H.V.Inskeep. *Am. Welding Soc.—Jl.*, v 10, Oct '31, p 21-4. Research work at Union Carbide and Carbon Research Laboratories to determine best types of joint.

Pipe Joints. Four Problems Encountered in Flash Welding Mild Steel, E.R.Torgler. *Am. Welding Soc.—Jl.*, v 10, Sept '31, p 29-33. Welding methods in manufacture of Dresser type couplings of 8 to 26 in. diam. with particular regard to flash welding of mild steel middle ring; determination of necessary flash and upset (burn and jam) for satisfactory middle ring flash weld; photomicrograph illustrates structure; secondary piping and segregated impurities as causes of defective flash welds; comparison between flash weld and roll weld.

Pipe Lines. Welded Pipe and Fittings in Heating Installations, F.J.Maeurer. *Am. Welding Soc.—Jl.*, v 10, Sept '31, p 5-13. Efficiency; economy; weight saving; fabrication of joints; fabrication of headers; welding fittings; spacing and tacking; expansion and contraction; adaptability and portability of oxyacetylene apparatus; welding piping in home; reduction of friction loss in welded fittings.

Rails. The Electric Welding of Battered Rail Ends. *Engineering*, v 132, Oct 2, '31, p 452. Canadian Pacific Railway authorities have been experimenting, during past 3 years, in hope of developing economical means of building up battered rail ends by electric welding.

Committee on Welded Rail Joints—Progress Report No. 7. New York, American Bureau Welding, A.E.R.E.A. and U.S. Bureau Standards. May '31, 62 p. Outline of following Bureau of Standards progress reports: Preheating and Postheating; Hardness Tests Along Thermit Welded Unit; Hardness Tests Along Thermit Welded Rail Joint; Metallographic Examination of Thermit Welded Rail Joint; Results of Shearing Tests of Small Preheated and Postheated Welded Specimens of Investigation No. 3 Revised; Repeated Impact Tests of Rail Joints of Investigation No. 2.

Structural Steel. Jig Assembly for Welding Fabrication Proves Its Efficiency. *Eng. News-Rec.*, v 107, Oct 29, '31, p 688-9. Fabrication of steel for new all-welded shop building at Barberton, Ohio, plant of Babcock & Wilcox Co.; results showed 10 per cent saving over estimate for riveted building.

Report of Structural Steel Welding Committee. *Am. Welding Soc.—Jl.*, v 10, Oct '31, p 25-42. Investigation extending over period of 5 years; determination of stresses that may be safely used in designing of welded steel structures fabricated under ordinary commercial fabricating shop conditions. (To be continued.)

WELDS

Testing. Stethoscopic Examination of Welded Products, J.R.Dawson. *Power Plant Eng.*, v 35, Oct 15, '31, p 1016-17. Hammer tests can be effectively used on welds; testing equipment and procedure. Before Am. Welding Soc and A.S.T.M.

X-Ray Analysis. X-Ray Examination of Welded Pressure Vessel Seams, A.J.Moses. *Combustion*, v 3, Sept '31, p 17-20 and 35. With recent formulation of A.S.M.E. code for welded boiler drums, technique and methods of testing used in manufacture of welded drums have taken on added interest and importance; outline of X-ray method of testing; features of installation of X-ray equipment which is representative of latest development in this field.

WHEATSTONE BRIDGE

A Voltage Selective Nonlinear Bridge, C.G. Suits. *Physics*, v 1, Sept '31, p 171-81. Important property of simple series resonance circuit employing resistance, capacitance and iron core reactor arranged to saturate is abrupt increase in current at certain critical voltage; this phenomenon is identified as quasi-resonant condition, and is compared to resonance in linear circuits; experimental study is made of nonlinear bridge circuit comprising two branches of above type.

Capacity. Two Precision Condenser Bridges, A.Campbell. *Phys. Soc.—Proc.*, v 43, Sept 1, '31, p 564-8. To facilitate direct reading of both capacitance and power-factor, the author has developed two bridge systems, based on that of Carey Foster.

Industrial Notes

Westinghouse and Italian Company to Exchange Patents.—According to F.A. Merrick, president of the Westinghouse Electric & Manufacturing Company, an agreement has been concluded with Ercole Marelli & Company of Milan, a leading Italian electrical manufacturing concern, for an exchange of patents and experience. The Westinghouse companies will not participate financially nor take any part in the management of the Italian company.

Square D Promotions.—C. Lewis Hull, sales manager, switch and panel division of the Square D Company, announces the appointment of C. W. Bates, formerly Chicago branch manager, as assistant sales manager. G. S. Blomgren, of the Chicago office, succeeds Mr. Bates as Chicago branch manager. Mr. Bates' headquarters will be at the Detroit factory of the Square D Company.

The Corning Glass Works, Corning, N. Y., has appointed the Bra Bon Electric Company, Inc., with offices in the Lewis Tower Building, Philadelphia, as agents for the sale of PYREX power insulators. The territory covered will include parts of New Jersey, Pennsylvania, Maryland, District of Columbia and the states of Delaware and Virginia.

Herbert S. Glasby, who has been associated with the Acme Wire Company, of New Haven, Conn., has opened a sales office at 123 South Broad Street, Philadelphia. In addition to handling the line of magnet wire, coils, varnished insulations and condensers made by the Acme Wire Company, he will represent the National Harris Wire Company, of Newark, N. J., manufacturers of high resistance alloy wires and ribbons; the MacAllen Company, of Boston, producers of mica sheet, tapes and molded articles, and the Waterbury Button Company, Waterbury, Conn., makers of bakelite, durez and other high dielectric molded products.

A New Time Switch.—The Sangamo Electric Company, Springfield, Ill., has announced for January deliveries a very moderately priced, electrically wound time switch. The main spring, kept wound by a constant speed a-c. motor, has ten hour reserve power to carry through any ordinary current interruption. A jeweled balance with non-magnetic, non-rusting, temperature compensating, special alloy hairspring, guarantees dependable timing. One of the unique features of this new switch is the type of mechanical contact which is being introduced in this country, after being used successfully abroad for many years. This new contact has a slow opening and a small gap. It is revolutionary, but has been thoroughly tested and is guaranteed by the makers. The standard switch has levers for three complete daily operations, allowing for either one, two, or three, on and off periods each day. Manual operation does not affect the sequence of subsequent operations. A Sunday and holiday cutout is also supplied. The entire timing and winding mechanism is enclosed in a dust-proof case. This unit, complete with contact mechanism and molded bakelite connection block, is mounted in a pressed steel case.

An Improved Lamp Cord.—The Simplex Wire & Cable Company, Boston, has introduced "Latox" rubber sheathed twin lamp cord, a new type of flexible, rubber insulated cord suitable for portable lamps, fans, clocks, toys and similar apparatus. It is a small, durable cord with a thin covering or sheath of tough, new type, rubber compound in place of the usual silk, rayon or cotton braids. The rubber sheath is furnished in black, green, or brown-mahogany and retains a satin-smooth, highly polished finish indefinitely. The advantages claimed for the new cord are that it will never fray, it does not gather dust or lint, is sanitary, will not absorb moisture, and wiping with a damp cloth restores its freshness when soiled.

Trade Literature

Instrument Transformers.—Catalog GEA-601C, 42 pp. Describes General Electric standard lines of switchboard, portable and laboratory instruments. Dimensions and typical scales of certain lines are included. General Electric Company, Schenectady, N. Y.

Illuminating Equipment.—Bulletin, Serial No. 754, 28 pp., "Planned Lighting," described as a comprehensive manual for planning almost every form of illumination. Illustrated and includes detailed sketches and data on wattage capacities. Curtis Lighting, Inc., 1123 W. Jackson Blvd., Chicago.

Motors.—Bulletin 167, "Small Motors," 30 pp. The bulletin, in loose-leaf form, is divided into eight parts describing single-phase, polyphase and direct-current motors in fractional horsepower ratings. At present only five of the eight parts are available, but the missing three parts will be mailed at a later date to all who request a copy of No. 167 at this time. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis.

Illuminometer.—Bulletin 4 pp. Describes a new instrument which reads illumination intensities with the same ease and facility as reading ammeters and voltmeters. Known as the Model 603 Illuminometer, it consists of an indicating instrument and a light target assembled in a portable case. The light target is on the end of a flexible cord so that it may be placed in any position. This light target, or searching unit has two photronic cell units which convert light energy directly into electrical energy without the use of batteries or other auxiliary voltage. They maintain constant output over long periods of time and there is no dark current. The output from the photronic cell units is considerable, allowing the use of a rugged portable instrument calibrated directly in foot-candles. There are three ranges on the instrument, namely, 10, 50 and 250 foot-candles. A range changing switch is provided for the selection of the desired scale. Other combinations of ranges are being added to the line and will be available shortly. The light target may be placed at a distance from the observer so that shadows and lights reflecting from light clothing will not cause errors in readings. Light may be read from all angles and the light target may be placed in relatively inaccessible places, in show cases, windows, etc. The absorption of light by painted walls, screens draperies, etc., can be measured directly by turning the light target so that it faces the surface. The time required to make a lighting survey is about one-tenth of that previously required. Weston Electrical Instrument Corp., 584 Frelinghuysen Ave., Newark, N. J.

Bus Connectors.—Catalog 31, 96 pp. Describes "Memco" bus connectors and ground fittings. In addition to conventional designs of clamped and soldered bus connectors, two original and unique designs in clamped connectors are presented. One is the "Pliaband" design, which is a bolted connector, so designed as to adapt itself to the minor irregularities and variations in the circumference of the bus. It is primarily a high capacity fitting for important connections. The "Wedge-Grip" connectors are, as the name implies, based on the use of high pressure contact as secured from the wedge principle. Each connector of this type accommodates from eight to twelve sizes of wire and cable. In addition, a complete line of fittings are listed for modern "flat type" substations. The engineering section of the catalog contains a number of original tables and charts which will be found very helpful as short cuts in substation design work. It also includes the principal NEMA standards as relating to outdoor substation practise. Memco Engineering & Manufacturing Co., Inc., 37 Ninth Street, Long Island City, N. Y.